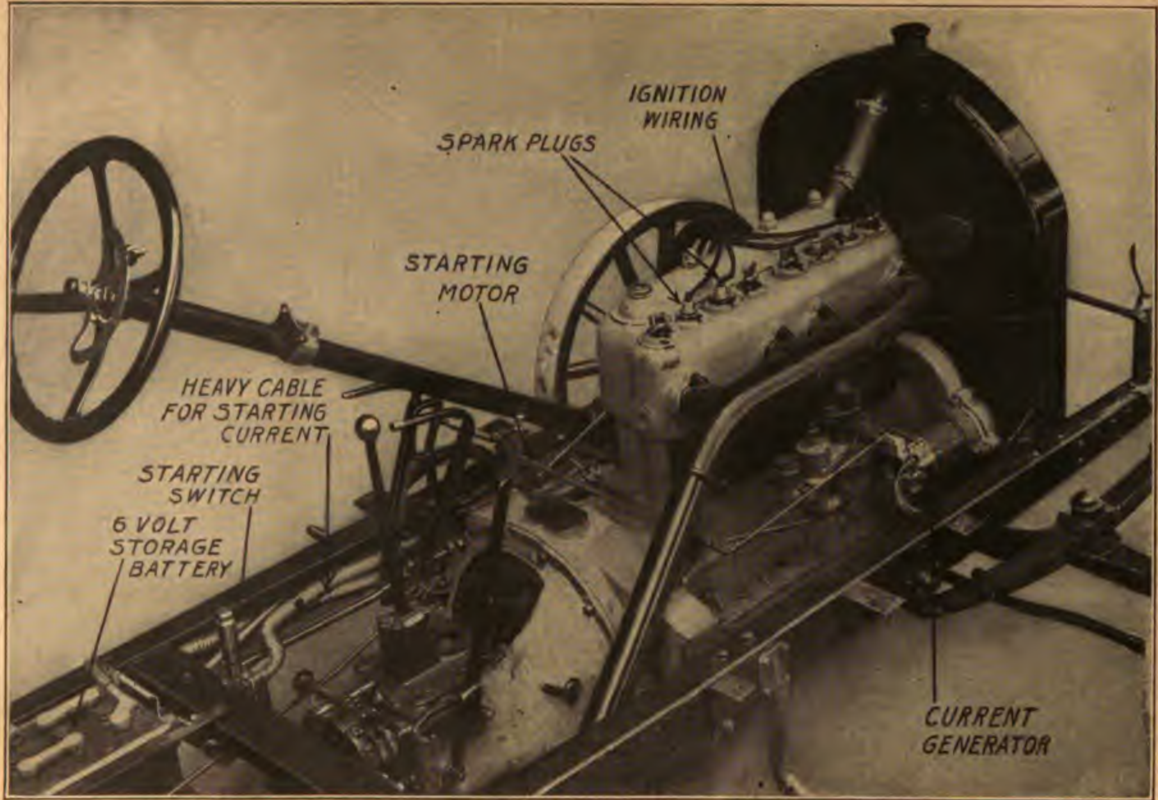

Frontispiece.—View of Modern Automobile Chassis, Showing Location of Power Plant and Parts of Electric

STARTING, LIGHTING AND IGNITION SYSTEMS

ELEMENTARY PRINCIPLES — PRACTICAL APPLICATION — WIRING DIAGRAMS AND REPAIR HINTS

A COMPLETE EXPOSITION EXPLAINING
ALL FORMS OF ELECTRICAL IGNITION SYSTEMS USED WITH
INTERNAL COMBUSTION ENGINES OF ALL TYPES, ALSO INCLUDES
A COMPREHENSIVE SERIES OF INSTRUCTIONS PERTAINING
TO STARTING AND LIGHTING SYSTEMS OF AUTOMOBILES

Describes
Storage Battery Construction and Maintenance, Magneto Timing—Care of Motors and Generators and Systematic Location of All Electrical Faults

INVALUABLE TO MOTORISTS, STUDENTS, MECHANICS AND REPAIR MEN
EVERY PHASE OF THE SUBJECT IS TREATED IN AN EASILY
UNDERSTOOD, NON-TECHNICAL MANNER

BY

VICTOR W. PAGÉ, M. E.

Member Society of Automobile Engineers; author of "Automobile Repairing Made Easy," etc., etc.

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NEW YORK
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INTRODUCTION

There has been no part of the automobile that has been changed more often than the ignition system. The first cars had simple battery and coil ignition, then with the introduction of the high tension magneto the systems were usually combined on the same engine in order to secure double ignition systems, either one being independent of the other. Later, as the magneto became refined and improved, a number of makers discarded the battery ignition system and placed their entire reliance on the magneto. With the coming of the demand for electrical motor starting and lighting systems came a revival of the battery ignition method which had been discarded for the high tension magneto. The main reason for using the magneto in preference to the battery system was that ignition became weaker with the latter after the engine had been run for a time owing to a lessened output of the battery. The magneto which generates electricity by a mechanical process had the advantage because the faster it was driven the more current it delivered.

In the modern automobiles an electrical current generator is provided, run by the engine which is depended on to charge a storage battery while the motor is running, the current for ignition and lighting being taken from the storage battery instead of directly from the generator which delivers a current of varying output depending upon the engine speed which in turn regulates the rate of generator armature rotation. On many cars therefore, the battery ignition systems are used as the use of the generator keeps the battery charged always to the proper point for securing energetic ignition. The automobile repairman will have cars to repair that will use a wide variety of ignition systems, as many of those fitted with the simple battery and coil are still in use while a very large number are equipped solely with the high tension magneto. Many of the newer cars use improved battery ignition systems with the high tension magneto eliminated.

One of the pronounced developments of the last two or three years has been the general adoption of various starting means for setting the engine in motion without recourse to the usual form of hand crank. Some of these motor starting systems merely replace the usual hand crank with some means of turning the motor over without leaving the seat by purely mechanical connections. Others, on 1912 and 1913 models of a few cars, depend on air pressure, while the most popular and generally applied forms to 1916 model cars depend on electricity as a source of power for a small electric starting motor. Electric starting and lighting systems have been made in many forms, though the basic principles of operation are practically the same in all systems that can be grouped in several main classifications. It will not be possible to describe all in a general treatise of this nature, but if the features of the leading systems are outlined it will not be difficult for the repairman or student to become familiar with the principle of other systems which may be slightly different only in points of minor detail. Not only are the various parts of leading systems shown, but as a result of the co-operation of the leading automobile manufacturers, the author is enabled to show the actual application of the various ignition, generating and starting units to leading power plants. While a certain amount of technical exposition is unavoidable, everything has been stated as simply as possible so readers without technical knowledge can understand the principles and method of operation, as well as location of troubles in the popular systems. The illustrations have been carefully selected and all wiring diagrams are of representative systems actually in use. The reader not versed in electrical science will find that careful perusal of the chapter on "Elementary Electricity and Magnetism" will enable him to understand many of the more technical descriptions and wiring diagrams. As electricity is used for operating many accessory devices besides the lighting, ignition and motor starting units, a chapter is devoted to the unusual applications of the electric current.

THE AUTHOR.

March, 1916.

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STARTING, LIGHTING AND IGNITION SYSTEMS

CHAPTER I

ELEMENTARY ELECTRICITY

Nature of Electricity—Why Current Flows—Parts of Circuit—Conductors and Insulators—Methods of Producing Electricity—How Primary Battery Generates Current—Wiring Dry Cells—How Storage Battery Works—Magnetism—Current Production by Induction—Magneto Action—Low Tension Magneto—High Tension Systems—Dynamo and Motor Action—Methods of Winding—Electrical Terms Defined—Electrical Measuring Instruments.

MANY forces exist in the universe the character of which have never been solved and may never be to the end of the world. We know these forces exist because their presence is made known by well understood phenomena. Among these forces gravitation, light, electricity and magnetism are prominent and even in this advanced age no one has a very clear conception of the nature of any of these forces nor would a presentation of theory and surmise be of any material benefit to those who are more concerned with the practical utility and the way these forces can be made of value to man than with a scientific presentation of theoretical causes.

Nature of Electricity.—A knowledge of electricity is of great value in permitting the reader to grasp clearly the principles underlying the operation of the various units comprising the ignition, starting and lighting systems of the modern motor car. If the following explanations are carefully studied it will be possible for one without any previous electrical training to understand intelligently the functions of electrical appliances and make it easier to locate and remedy troubles that are apt to materialize in these appliances. Electricity is a form of energy and is known because

it is capable of doing work. The passage of electricity through any piece of apparatus is termed a current. If the flowing of the electrical charges is continuous it is called a direct current. If the charges are not continuous but flow always in the same direction it is termed a "pulsating" current. If an electrical charge flowing in one direction is followed by another charge flowing in the opposite direction, an "alternating" current is produced.

It will be evident that to obtain a regular flow a constant supply of electricity, such as afforded by some electrical generator is required. The simplest analogy to permit the reader to understand the passage of a current is the flow of a stream of water. A number of comparisons can be made between water and the electric current which tend to simplify the explanation, though it is understood that there can be little in common between such a tangible fluid as water is and electricity which is intangible and only considered a fluid for convenience. To form some conception of this force, it is well to consider that we are able to place various bodies in different electrical relations. A stick of sealing wax or a hard rubber comb, rubbed on a coat sleeve, will attract bits of paper, feathers and other light objects. The sealing wax or rubber is said to be charged with electricity which has been produced by friction against the coat sleeve. Any body charged with electricity may be considered one whose surface is supplied with either an overcharge or undercharge of electricity. The overcharged body always tends to discharge to the undercharged body in order to equalize a difference in pressure existing between them. An electrical machine capable of producing current may distribute this current as desired, providing the current is sufficiently strong to overcome the resistance to its motion of the parts comprising the external circuit.

Why Current Flows.—The action of an electrical machine in regulating the distribution of electricity may be considered to be the same as that of a pump which takes water from one tank and supplies it to another at a higher level. If for these reservoirs we consider bodies insulated from each other, we can, with an electrical generator take electricity from one that has been overcharged and supply it to another which is undercharged. If we had two

tanks of water at the same level, one container being full and the other nearly empty, merely connecting these with the pipe in which a valve was placed would permit the water from the full reservoir to pass into the nearly empty one, till both contained equal amounts of liquid. As is the case with tanks of water if two bodies are charged with unequal amounts of electricity the electrical charge will tend to equalize itself when the two bodies are connected together with a conductor that will allow the passage of electricity. Any time the flow of water from one tank to the other is to be interrupted, up to that point when equilibrium is reached, closing the valve will obstruct the conductor and shut off the flow of water.

It is possible to utilize a switch in the electrical conductor, which will do the same thing as the valve does in the water pipe. Water cannot flow through the closed valve because of the resistance the valve offers. If the valve is weak and the water pressure is sufficiently high it is possible for the water to burst the restraining walls in the valve and continue to flow. It is evident therefore that the strength of the valve parts must be proportioned according to the pressure of the water stream. A switch interposed in an electrical conductor will, when opened, leave an air gap in this conductor that offers so much resistance to the flow of current that the electricity cannot pass. Closing the switch so that the continuity of the conductor is re-established will enable the current to flow. An electrical circuit is different from a water circuit, inasmuch as electricity must always return to its source. The greater the difference in the quantities of the electrical charge the greater the tendency to reach the state of equilibrium. This difference in electrical conditions or amount of electrical charge is termed "difference of potential," and high or low potential or "electro motive force" in any electrical system indicates a large or small difference of charge or electrical condition at different parts. Just as in the case of the tanks filled with different amounts of water, and in which as a result there is a difference of level, the flow is always through a conductor from the point of higher to that of lesser potential. If we had a tank of water ten feet from the ground the water would flow faster through a certain size hole than if the tank were but two feet from the ground. Not only would the tank be

emptied quicker but the water would have a greater head or pressure. The same condition exists on electrified bodies as the greater the difference of potential or level between them the more rapid the flow and the greater the pressure of the current.

The levels of liquids in the tanks instead of being compared to each other might be referred to that of an ocean of constant level. Water might be pumped into the ocean from one or from the ocean to one or both so as to affect the level of water in the tanks with respect to the larger quantity in the ocean of constant height. Electricity can be considered in the same manner. It can be taken

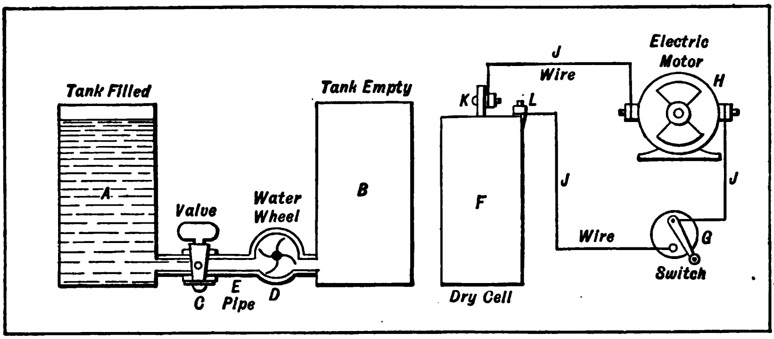


Fig. 1.—Diagrams Illustrating How Current Pressure Causes Electricity to Flow by Comparing It to a Flow of Water from One Tank to Another.

from an ocean of electricity, which may be represented by the electrical charge present at all points of the earth or the earth can be used, as it invariably is, as a receptacle for the charges obtained from electrical producers.

In Fig. 1 is shown two tanks, A and B, connected by a pipe. Let tank A, which is filled with water, represent the positive element K of the cell F, and the empty tank B the negative element L. Let pipe E connecting the two tanks represent wires J connecting the two elements. It is evident that water will flow through the pipe from the full tank to the empty tank until both contain the same quantity and the pressures are equal. Likewise in the battery cell electricity will flow through the wire from the positive

element K to the negative element L, until the pressures on both are equal, when the current will stop flowing and the cell will be discharged. If a valve C is placed in the pipe, connecting the two tanks, the flow of the water may be stopped. If a switch G is placed on the wire connecting the two elements the flow of electricity may be stopped. If a water wheel D is placed in the pipe the flowing water may be made to do work. If a small motor H is placed on the wire J the flowing electricity may be made to do work. In automobile use this work is done in charging the induction coil for ignition purposes, producing light, etc. The weight of the water in tank A gives a certain pressure. The similar pressure in the electric battery is measured in volts. The pressure of the water causes a quantity to flow through the pipe. The similar quantity of electricity that is forced over a wire from a battery is measured in amperes.

Parts of Circuit.—To retain water the tank walls must have a certain degree of strength which is determined entirely by the size of the tank and the height above ocean level. To enable objects to hold an electrical charge they must be surrounded by something that will retain it. Any substance which holds a charge upon its surface and does not permit it to flow thereby corresponding to the walls of water reservoirs is termed an insulator. Some substances conduct electricity, others resist its flow. If two water tanks were connected by a rod of metal the water could not flow from one to the other. The rod of metal must be hollow to permit the water to pass through it. Solid metal is a barrier or insulator that prevents the passage of water. A pipe is a conductor of water. If two electrically charged bodies are connected by a piece of wood, glass, rubber, dry cloth, paper or similar materials there will be no passage of electricity, but if a metal rod is substituted, a current will flow from the body of higher potential to the other. In this case the metal rod or wire is a conductor of electricity. All metals and substances such as acid, water and the various liquids (except oils) conduct electricity so well as to be termed "conductors" though it is harder for the electrical current to flow through some kinds of metal than it is for it to pass through others. Copper, aluminum and silver are very good elec-

trical conductors, steel or iron is next in order, while some alloys, such as German silver, offer considerable resistance to the flow of current.

Materials such as wood, glass, rubber, etc., and air, conduct electricity so badly as to be termed insulators. What would normally be an insulator to a current of low potential may be ruptured by a current of higher potential or pressure which can break down the resistance. From the foregoing it will be evident that a current is produced by the passage of electricity from one body to another and that current can only flow through certain materials and that some substances act as a barrier to the current flow just as a valve stops the flow of water. With a valve in the water pipe, providing that the parts were sufficiently strong, closing the valve breaks the continuity of the pipe and stops the flow of water. The same is true of electricity, it must have a complete circuit or the currents cannot pass. An electrical circuit is said to be an open circuit when the current cannot flow and a closed circuit, if there is a continuous path for the electricity.

A closed circuit therefore is one made up entirely of apparatus and wires capable of conducting electricity, including some form of generator of electrical energy which acts as a pump to produce a flow. The flow of current is from the electrical generator, through wires to the piece of apparatus to be operated and from that piece of apparatus back again to its source. If we connect the terminals of the battery through the wire to the bell, after energizing the bell magnets the electricity does work by ringing the bell. It flows from the positive or carbon terminal of the battery through the wire to the bell and after energizing the bell magnets, it returns through another conductor to the zinc or negative terminal of the battery. Inside of the cells, the flow is from the negative member to the positive member. Any closed circuit may be made an open circuit by including an insulating body which resists current flow. This body is always of such a form that it can be temporarily bridged over by a conductor when it is desired that the current pass through the circuit. All electrical circuits must comprise a source of current, wires to carry it, a switch to interrupt it and apparatus to be actuated by it.

Current Production by Chemical Action.—The simplest method of current generation is by various forms of chemical current producers which may be either primary or secondary in character. A simple form of cell is shown in section at Fig. 3, A, and as the action of all devices of this character is based on the same principles it will be well to consider the method of producing electricity by the chemical action of a fluid upon a metal. The simple cell shown

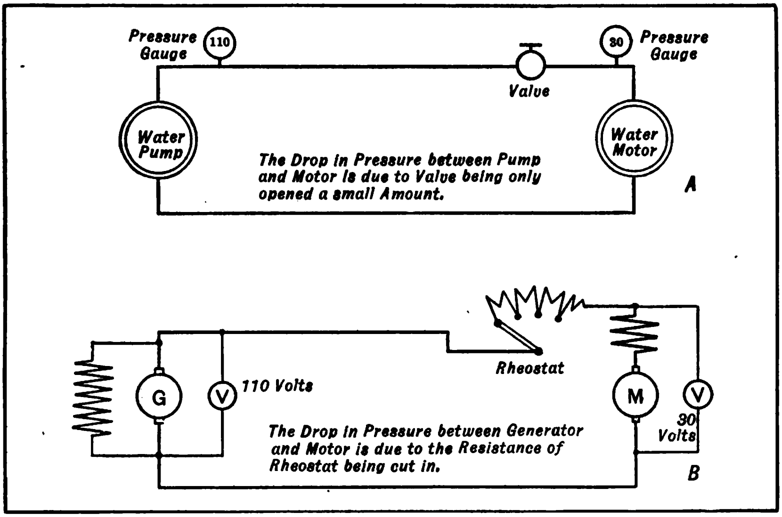


Fig. 2.—Diagrams Outlining How Current Voltage is Reduced by Increasing Resistance in Circuit. A—Water Flow Reduced by Shut-off Valve. B—Electric Flow Reduced by Rheostat, an Equivalent of the Valve in the Water System.

consists of a container which is filled with an electrolyte which may be either an alkali or acid solution. Immersed in the liquid are two plates of metal, one being of copper, the other zinc. A wire is attached to each plate by means of suitable screw terminals.

If the ends of the plates which are not immersed in the solution are joined together a chemical action will take place between the electrolyte and the zinc plate; in fact, any form of cell consists of dissimilar elements which are capable of conducting electricity im-

mersed in a liquid which will act on one of them more than the other. The chemical action of electrolyte on the zinc liberates gas bubbles which are charged with electricity and which deposit themselves on the copper plate. The copper element serves merely as a collecting member and is termed the "positive" plate, while the zinc which is acted upon by the solution is termed the "negative" member. The flow of current is from the zinc to the copper plate through

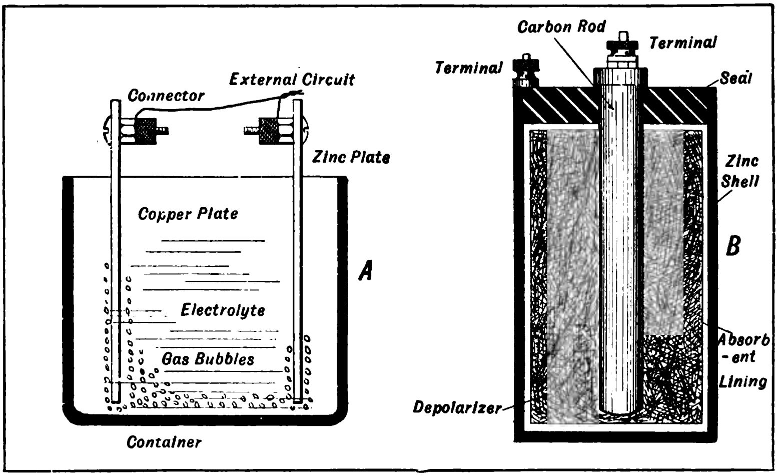


Fig. 3.—Simple Primary Cell Used to Produce Electric Current. A—Form to Show Principle of Current Production by Chemical Action. B—Dry Cell, the Type Suitable for Automobile Service.

the electrolyte and it is returned from the copper plate to the zinc element by the wiring which comprises the external circuit.

While in the cell shown zinc and copper are used, any other combination of metals between which there exists a difference in electrical condition when one of them is acted upon by a salt or acid may be employed. Any salt or acid solution will act as an electrolyte if it will combine chemically with one of the elements and if it does not at the same time offer too great a resistance to the passage of the electric current. The current strength will vary with the nature of the elements used, and will have a higher value

when the chemical action is more pronounced between the negative member and the electrolyte.

As the vibrations which obtain when the automobile is driven over highways makes it difficult to use cells in which there is a surplus of liquid, a form of cell has been devised in which the liquid electrolyte is replaced by a solid substance which cannot splash out of the container even if the cell is not carefully sealed. A current producer of this nature is depicted in section at Fig. 3, B. This is known as a dry cell and consists of a zinc can in the center of which a carbon rod is placed. The electrolyte is held close to the zinc or negative member by an absorbent lining of blotting paper, and the carbon rod is surrounded by some depolarizing material. The top of the cell is sealed with pitch to prevent loss of depolarizer.

The depolarizer is needed that the cell may continue to generate current. When the circuit of a simple cell is completed the current generation is brisker than after the cell has been producing electricity for a time. While the cell has been in action the positive element becomes covered with bubbles of hydrogen gas, which is a poor conductor of electricity and tends to decrease the current output of the cell. To prevent these bubbles from interfering with current generation some means must be provided for disposing of the gas. In dry cells the hydrogen gas that causes polarization is combined with oxygen gas evolved by the depolarizing medium and the combination of these two gases produces water which does not interfere with the action of the cell. Carbon is used in a dry cell instead of copper because it is a cheaper material and the electrolyte is a mixture of salammoniac and chloride of zinc which is held in intimate contact with the zinc shell which forms the negative element by the blotting paper lining.

Wiring Dry Cells.—When dry cells are used for ignition there are two practical methods of connecting these up. At least four dry cells are necessary to secure satisfactory ignition and much more energetic explosions will be obtained if five or six are used. The common method is to join the cells together in series as shown at Fig. 4, A. When connecting in this manner the carbon terminal of one battery is always coupled to the zinc binding post of its

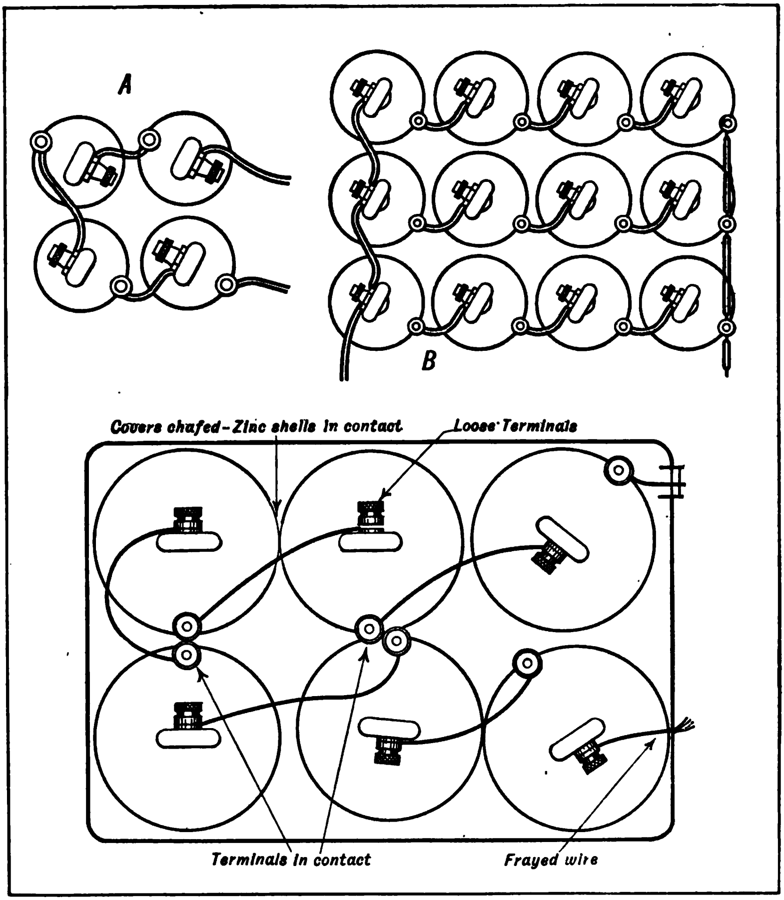


Fig. 4.—Methods of Connecting Dry Cells and Precautions to be Observed When Wiring.

neighbor. Connection would be made from the carbon of the first cell to the zinc of the second, from the carbon of the second to the zinc of the third, and from the carbon of the third to the zinc of the fourth, this leaving the zinc terminal on the first cell and the carbon terminal on the fourth cell free to be joined to the external circuit. When dry cells are connected in series the

voltage is augmented, that of one cell being multiplied by the number so joined. The amperage remains the same as that of one cell. If a dry cell has a potential of 1¼ volts, a battery composed of four cells would show 5 volts. When dry batteries are used for lighting purposes or for igniting multiple cylinder engines, in order to obtain better results, they are connected in series multiple, as shown at B. Three sets of cells joined in series are placed side by side with the free carbons at one end in line and the zincs at the other also in line. The three carbons are then joined together by one wire, the three zinc terminals by another. When joined in this manner the battery has a voltage equal to that of four cells and an amperage equal to that of three cells. If a series connected battery as at A indicates 5 volts and 20 amperes, the series multiple connection at B will indicate 5 volts and 60 amperes. When cells are joined in multiple the drain on any one cell is reduced and it is not so likely to become exhausted as when four are used in series. The points to be watched out for when installing dry batteries are clearly outlined at the bottom of Fig. 4. It will be seen that it is not desirable for terminals to come in contact with each other or with the sides of the box or is it conducive to good ignition to have the zinc shells in contact. A loose terminal on any one of the batteries will result in irregular ignition while a broken wire will interrupt it altogether. If the insulation is frayed where a wire passes through a hole in a metal battery box trouble may be experienced due to short circuiting of the current between the bare wire and the steel box, which may be grounded.

One of the disadvantages of primary cells, as those types which utilize zinc as a negative element are called, is that the chemical action produces deterioration and waste of material by oxidization. Dry cells are usually proportioned so that the electrolyte and depolarizing materials become weaker as the zinc is used and when a dry cell is exhausted it is not profitable to attempt to recharge it because new ones can be obtained at a lower cost than the expense of renewing the worn elements would be.

The number of dry cells necessary will vary with the system of ignition employed and the size of the motor. While two or three

cells will ignite small engines such as used in motorcycles, five or six will be needed on automobile engines employing high-tension ignition. When the make-and-break system, or low-tension method, is used eight or ten cells are necessary. If the engine is a multiple cylinder one, it will draw more current than a single cylinder type because of the greater frequency of sparks. On four-cylinder cars dry cells should be joined in multiple series, which is the most economical arrangement. Cells used in multiple connection are more enduring than if the same number were used independently in single-series connection. A disadvantage of a dry cell battery is that it is suited only for intermittent service and it will soon become exhausted if used where the current demands are severe. For this reason most automobiles in which batteries are used for ignition employ storage or secondary batteries to furnish the current regularly used and a set of dry cells is provided for use only in cases of emergency when the storage battery becomes exhausted.

Principles of Storage Battery Construction.—Some voltaic couples are reversible, i. e., they may be recharged when they have become exhausted by passing a current of electricity through them in a direction opposite to that in which the current flows on discharge. Such batteries are known as "accumulators" or "storage batteries." A storage battery belies its name as it does not store current and its action is somewhat similar to that of the simpler chemical cell previously described. In its simplest form a storage cell would consist of two elements and an electrolyte, as outlined at Fig. 5, A. The storage battery differs from the primary cell in that the elements are composed of the same metal before charging takes place, usually lead instead of being zinc or carbon. One of the plates is termed the "positive" and may be distinguished from the other because it is brown, or chocolate in color after charging, while the negative plate is usually a light gray of leaden color. The active material of a charged storage battery is not metallic lead but oxides of that material.

The simple form shown at A consists of two plates of lead which are rolled together separated by insulating bands of rubber at the top and bottom to keep them from touching. This roll is immersed in an electrolyte composed of a weak solution of sul-

phuric acid in water. Before such a cell can be used it must be charged, which consists of passing a current of electricity through it until the lead plates have changed their nature. After the charging process is complete the lead plates have become so changed in nature that they may be considered as different substances and a chemical action results between the negative plate and the electrolyte and produces current just as in the simple cell

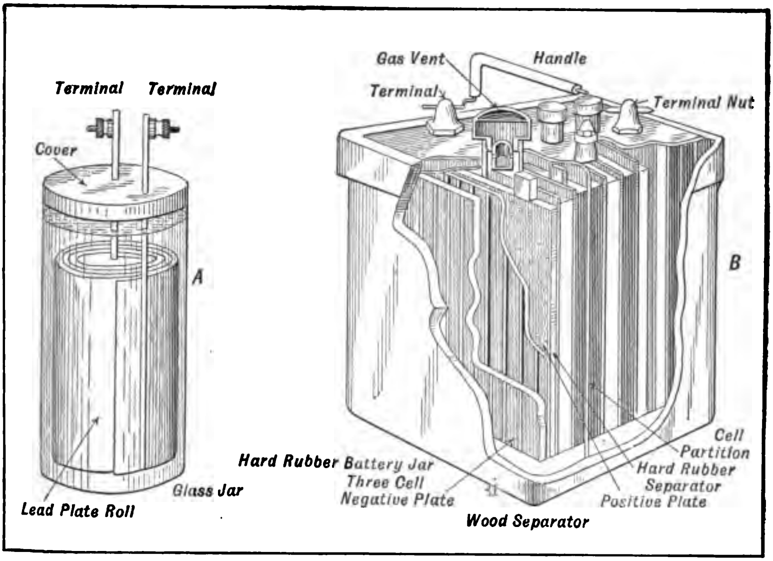


Fig. 5.—Types of Accumulators or Storage Batteries. A—Simple Form of Cell. B—Battery Composed of Three Cells Such as Commonly Used for Ignition Purposes.

shown at Fig. 3, A. When the cell is exhausted the plates return to their metallic condition and are practically the same, and as there is but little difference in electrical condition existing between them, they do not deliver any current until electricity has been passed through the cell so as to change the lead plates to oxides of lead instead of metallic lead.

When storage cells are to be used in automobile work they are combined in a single containing member, as shown at Fig. 5, B,

which is a part sectional view of a Geiszler storage battery. The main containing member, a jar of hard rubber, is divided into three parts. Each of these compartments serves to hold the elements comprising one cell. The positive and negative plates are spaced apart by wood and hard rubber separators which prevent short circuiting between the plates. After the elements have been put in place in the compartments forming the individual cells of the battery, the top of the jar is sealed by pouring a compound of pitch and rosin, or asphaltum, over plates of hard rubber, which keeps the sealing material from running into the cells and on the plates. Vents are provided over each cell through which gases produced by charging or discharging are allowed to escape. These are so formed that while free passage of gas is provided for, it is not possible for the electrolyte to splash out when the vehicle is in motion.

It will be evident that this method of sealing would not be practical on a cell where the members attacked by the acid had to be replaced from time to time, but in a storage battery only the electrolyte need be renewed. When the plates are discharged they are regenerated by passing a current of electricity through them. New electrolyte or distilled water can be easily inserted through holes in which the vents are screwed. The cells of which a storage battery is composed are joined together at the factory with bars of lead which are burned in place and only two free terminals are provided by which the battery is coupled to the outer circuit.

The capacity of a storage battery depends upon the size and the number of plates per cell, while the potential or voltage is determined by the number of cells joined in series to form the battery. Each cell has a difference of potential of two and two tenths volts when fully charged, therefore a two-cell battery will deliver a current of four and four tenths volts and a three-cell type, as shown in part section at Fig. 6, will give about six and six tenths volts between the terminals. In the form shown each cell is composed of a number of plates and their separators. One group of the plates is positive, the remaining negative members. The size of storage battery to be used depends upon the number of cylinders of the engine and also if battery is to be used for

starting and lighting purposes as well as ignition. Four-cylinder motors usually take a six-volt, sixty-ampere-hour battery, but it is desirable to supply a six-volt battery having eighty-ampere-hour capacity for six-cylinder motors for ignition only. For lighting or starting 100 ampere hour batteries are needed.

When chemical current producers are depended upon to supply the electricity used for ignition, two distinct sets are provided,

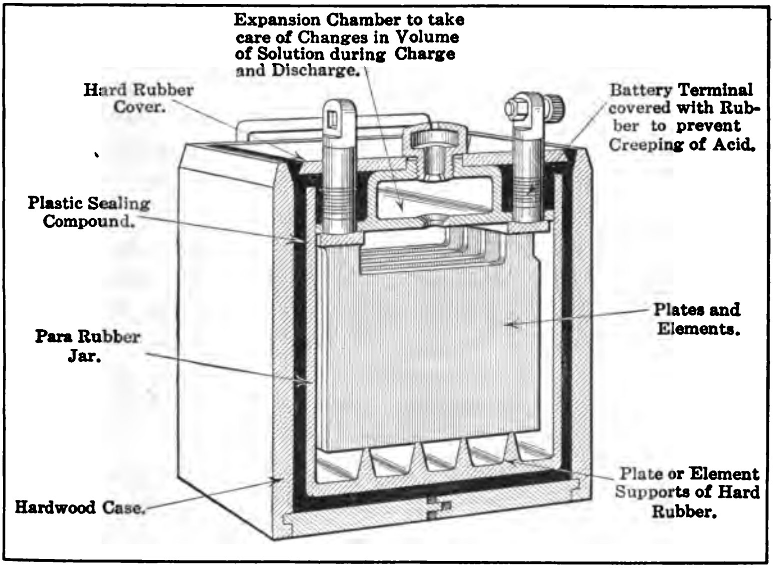


Fig. 6.—Special Storage Battery Designed to Furnish Lighting and Starting Current.

one for regular service and the other for emergency use in event of failure of that which is depended upon regularly. The common practice is to provide an accumulator or storage battery for normal use and a set of dry cells, which are cheaper in first cost and which do not deteriorate if not used for some time, for emergency service. When two sources of current are thus provided, a switch is included in the circuit so that either set may be used at will. The zinc terminal of the dry battery and the negative terminal of the storage battery are joined together by a suitable

conductor and are grounded by running the wire attached to them to some metal part of the chassis such as the crank case or frame side member. The remaining terminals, which are the positive of the storage battery and the carbon of the dry cell, are coupled to distinct terminals on the switch block.

The fact that any battery cannot maintain a constant supply of electricity has militated against their use to a certain extent and the modern motorist demands some form of mechanical generator driven from the power plant, which will deliver an unfailing supply of electricity and keep the battery charged. The strength of batteries is reduced according to the amount of service they give. The more they are used the weaker they become. The modern multiple cylinder engines are especially severe in their requirements upon the current producer and the rapid sequence of explosions in the average six- or eight-cylinder motor produce practically a steady drain upon the battery. When dry cells are used their discharge rate is very low and as they are designed only for intermittent work, when the conditions are such that a constant flow of current is required, they are unsuitable and will soon deteriorate. A more comprehensive discussion on the care, repair and charging of storage batteries will be found in the following chapter.

Fundamentals of Magnetism Outlined.—To properly understand the phenomena and forces involved in the generation of electrical energy by mechanical means it is necessary to become familiar with some of the elementary principles of magnetism and its relation to electricity. The following matter can be read with profit by those who are not familiar with the subject. Most persons know that magnetism exists in certain substances, but many are not able to grasp the terms used in describing the operation of various electrical devices because of not possessing a knowledge of the basic facts upon which the action of such apparatus is based.

Magnetism is a property possessed by certain substances and is manifested by the ability to attract and repel other materials susceptible to its effects. When this phenomena is manifested by a conductor or wire through which a current of electricity is flowing it is termed "electro-magnetism." Magnetism and electricity are

closely related, each being capable of producing the other. Practically all of the phenomena manifested by materials which possess magnetic qualities naturally can be easily reproduced by passing a current of electricity through a body which, when not under electrical influence, is not a magnetic substance. Only certain substances show magnetic properties, these being iron, nickel, cobalt and their alloys.

The earliest known substance possessing magnetic properties was a stone first found in Asia Minor. It was called the lodestone or leading stone, because of its tendency, if arranged so it could be moved freely, of pointing one particular portion toward the north. The compass of the ancient Chinese mariners was a piece of this material, now known to be iron ore, suspended by a light thread or floated on a cork in some liquid so one end would point toward the north magnetic pole of the earth. The reason that this stone was magnetic was hard to define for a time, until it was learned that the earth was one huge magnet and that the iron ore, being particularly susceptible, absorbed and retained some of this magnetism.

Most of us are familiar with some of the properties of the magnet because of the extensive sale and use of small horseshoe magnets as toys. As they only cost a few pennies everyone has owned one at some time or other and has experimented with various materials to see if they would be attracted. Small pieces of iron or steel were quickly attracted to the magnet and adhered to the pole pieces when brought within the zone of magnetic influence. It was soon learned that brass, copper, tin or zinc were not affected by the magnet. A simple experiment that serves to illustrate magnetic attraction of several substances is shown at A, Fig. 7. In this, several balls are hung from a standard or support, one of these being of iron or steel, the other two of any other of the common materials or metals. If a magnet is brought close to the group of balls, only one will be attracted toward it, while the others will remain indifferent to the magnetic force. Experimenters soon learned that of the common metals only iron or steel were magnetic.

If the ordinary bar or horseshoe magnet be carefully examined, one end will be found to be marked N. This indicates the north

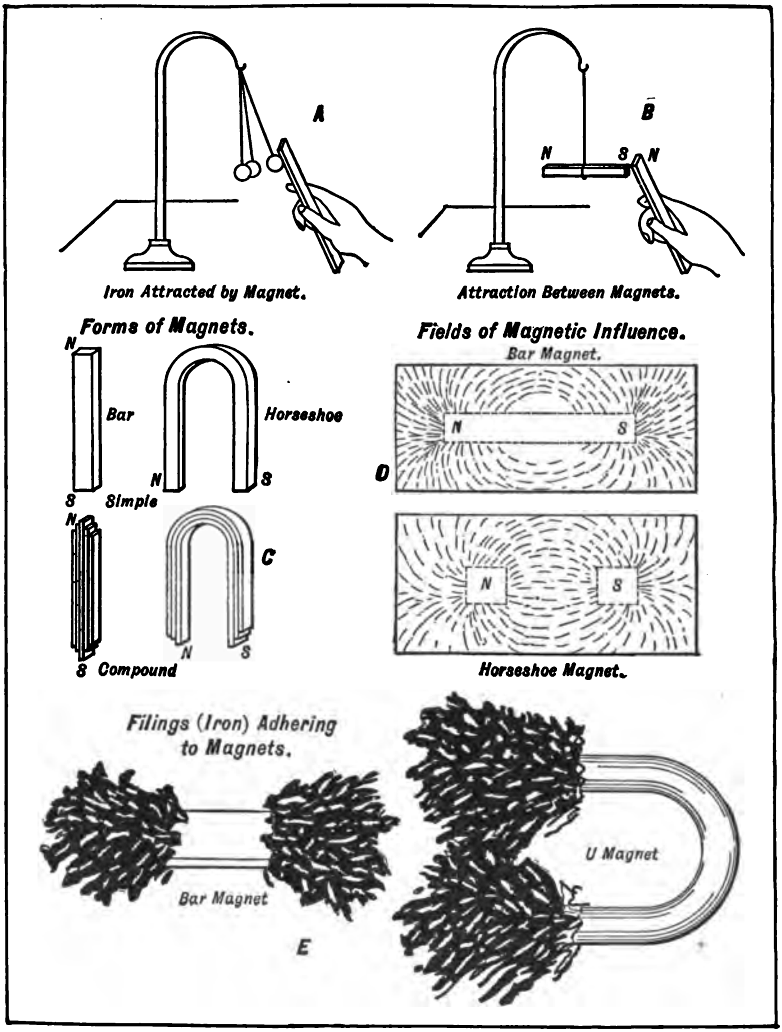


Fig. 7.—Some Simple Experiments to Demonstrate Various Magnetic Phenomena and to Clearly Outline Effects of Magnetism and Forms of Magnets.

pole, while the other end is not usually marked and is the south pole. If the north pole of one magnet is brought near the south pole of another, a strong attraction will exist between them, this depending upon the size of the magnets used and the air gap separating the poles. If the south pole of one magnet is brought close to the end of the same polarity of the other there will be a pronounced repulsion of like force. These facts are easily proved by the simple experiment outlined at B, Fig. 7. A magnet will only attract or influence a substance having similar qualities. The like poles of magnets will repel each other because of the obvious impossibility of uniting two influences or forces of practically equal strength but flowing in opposite directions. The unlike poles of magnets attract each other because the force is flowing in the same direction. The flow of magnetism is through the magnet from south to north and the circuit is completed by the flow of magnetic influence through the air gap or metal armature bridging it from the north to the south pole.

Forms of Magnets and Zone of Magnetic Influence Defined.—Magnets are commonly made in two forms, either in the shape of a bar or horseshoe. These two forms are made in two types, simple or compound. The latter are composed of a number of magnets of the same form united so the ends of like polarity are placed together, and such a construction will be more efficient and have more strength than a simple magnet of the same weight. The two common forms of simple and compound magnets are shown at C, Fig. 7. The zone in which a magnetic influence occurs is called the magnetic field, and this force can be graphically shown by means of imaginary lines, which are termed "lines of force." As will be seen from the diagram at D, Fig. 7, the lines show the direction and action of the magnetic force and also show its strength, as they are closer together and more numerous when the intensity of the magnetic field is at its maximum. A simple method of demonstrating the presence of the force is to lay a thin piece of paper over the pole pieces of either a bar or horseshoe magnet and sprinkle fine iron filings on it. The particles of metal arrange themselves in very much the manner shown in the illustrations and prove that the magnetic field actually exists.

The form of magnet used will materially affect the size and area of the magnetic field. It will be noted that the field will be concentrated to a greater extent with the horseshoe form because of the proximity of the poles. It should be understood that these lines have no actual existence, but are imaginary and assumed to exist only to show the way the magnetic field is distributed. The magnetic influence is always greater at the poles than at the center, and that is why a horseshoe or U-form magnet is used in practically all magnetos or dynamos. This greater attraction at the poles can be clearly demonstrated by sprinkling iron filings on bar and U magnets, as outlined at E, Fig. 7. A large mass gathers at the pole pieces, gradually tapering down toward the point where the attraction is least.

From the diagrams it will be seen that the flow of magnetism is from one pole to the other by means of curved paths between them. This circuit is completed by the magnetism flowing from one pole to the other through the magnet, and as this flow is continued as long as the body remains magnetic it constitutes a magnetic circuit. If this flow were temporarily interrupted by means of a conductor of electricity moving through the field there would be a current of electricity induced in the conductor every time it cut the lines of force. There are three kinds of magnetic circuits. A non-magnetic circuit is one in which the magnetic influence completes its circuit through some substance not susceptible to the force. A closed magnetic circuit is one in which the influence completes its circuit through some magnetic material which bridges the gap between the poles. A compound circuit is that in which the magnetic influence passes through magnetic substances and non-magnetic substances in order to complete its circuit.

How Iron and Steel Bars are Made Magnetic.—Magnetism may be produced in two ways, by contact or induction. If a piece of steel is rubbed on a magnet it will be found a magnet when removed, having a north and south pole and all of the properties found in the energizing magnet. This is magnetizing by contact. A piece of steel will retain the magnetism imparted to it for a considerable length of time, and the influence that remains is known as residual magnetism. This property may be increased by

alloying the steel with tungsten and hardening it before it is magnetized. Any material that will retain its magnetic influence after removal from the source of magnetism is known as a permanent magnet. If a piece of iron or steel is brought into the magnetic field of a powerful magnet it becomes a magnet without actual contact with the energizer. This is magnetizing by magnetic induction. If a powerful electric current flows through an insulated conductor wound around a piece of iron or steel it will make a magnet of it. This is magnetizing by electro-magnetic induction. A magnet made in this manner is termed an electro-magnet and usually the metal is of such a nature that it will not retain its magnetism when the current ceases to flow around it. Steel is used in all cases where permanent magnets are required, while soft iron is employed in all cases where an intermittent magnetic action is desired. Magneto field magnets are always made of steel alloy, so treated that it will retain its magnetism for lengthy periods.

Electricity and Magnetism Closely Related.—There are many points in which magnetism and electricity are alike. For instance, air is a medium that offers considerable resistance to the passage of both magnetic influence and electric energy, although it offers more resistance to the passage of the latter. Minerals like iron or steel are very easily influenced by magnetism and easily penetrated by it. When one of these is present in the magnetic circuit the magnetism will flow through the metal. Any metal is a good conductor for the passage of the electric current, but few metals are good conductors of magnetic energy. A body of the proper metal will become a magnet due to induction if placed in the magnetic field, having a south pole where the lines of force enter it and a north pole where they pass out.

We have seen that a magnet is constantly surrounded by a magnetic field and that an electrical conductor when carrying a current is also surrounded by a field of magnetic influence. Now if the conductor carrying a current of electricity will induce magnetism in a bar of iron or steel, by a reversal of this process, a magnetized iron or steel bar will produce a current of electricity in a conductor. It is upon this principle that the modern dynamo or magneto is constructed. If an electro-motive force is induced

in a conductor by moving it across a field of magnetic influence, or by passing a magnetic field near a conductor, electricity is said to be generated by magneto-electric induction. All mechanical generators of the electric current using permanent steel magnets to produce a field of magnetic influence are of this type.

Basic Principles of Magneto Action Outlined.—The accompanying diagram, Fig. 8, will show these principles very clearly. As stated earlier in this chapter, if the lines of force in the magnetic field are cut by a suitable conductor an electrical impulse will be produced in that conductor. In this simple machine the lines of force exist between the poles of a horseshoe magnet. The conductor, which in this case is a loop of copper wire, is mounted upon a spindle in order that it may be rotated in the magnetic field to cut the lines of magnetic influence present between the pole pieces. Both of the ends of this loop are connected, one with the insulated drum shown upon the shaft, the other to the shaft. Two metal brushes are employed to collect the current and cause it to flow through the external circuit. It can be seen that when the shaft is turned in the direction of the arrow the loop will cut through the lines of magnetic influence and a current will be generated therein.

The pressure of the current and the amount produced vary in accordance to the rapidity with which the lines of magnetic influence are cut. The armature of a practical magneto, therefore, differs materially with that shown in the diagram. A large number of loops of wire would be mounted upon this shaft in order that the lines of magnetic influence would be cut a greater number of times in a given period and a core of iron used as a backing for the wire. This would give a more rapid alternating current and a higher electro-motive force than would be the case with a smaller number of loops of wire.

The illustrations at Fig. 9 show a conventional double winding armature and field magnets of a practical magneto in part section and will serve to more fully emphasize the points previously made. If the armature or spindle were removed from between the pole pieces there would exist a field of magnetic influence as shown at Fig. 7, but the introduction of this component provides a con-

ductor (the iron core) for the magnetic energy, regardless of its position, though the facility with which the influence will be transmitted depends entirely upon the position of the core. As shown at

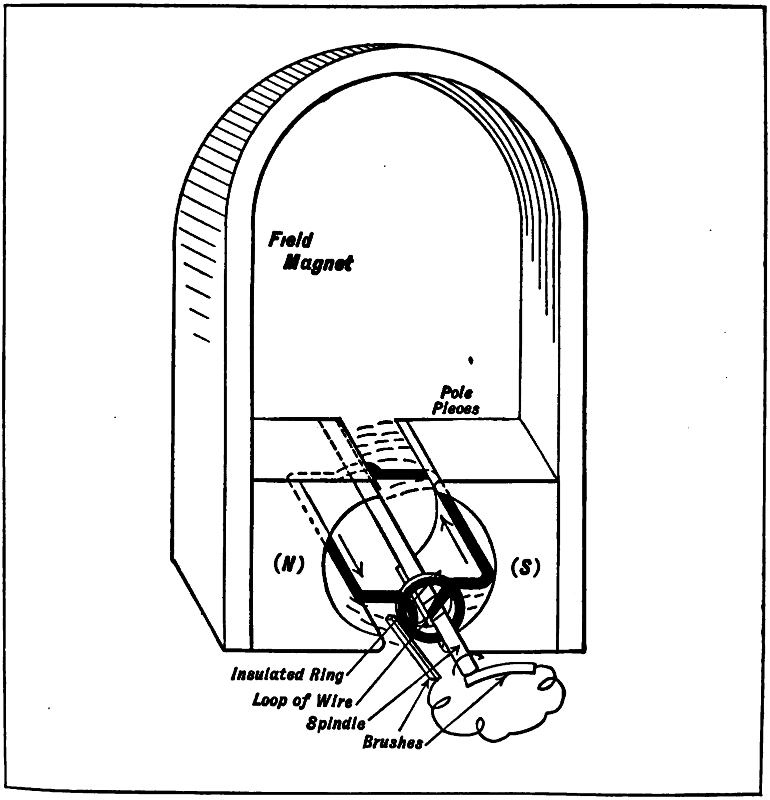


Fig. 8.—Elementary Form of Magneto Having Principal Parts Simplified to Make Method of Current Generation Clearer.

A, the magnetic flow is through the main body in a straight line, while at B, which position the armature has attained after one-eighth revolution, or 45 degrees travel in the direction of the arrow, the magnetism must pass through in the manner indicated. At C, which position is attained every half revolution, the magnetic

energy abandons the longer path through the body of the core for the shorter passage offered by the side pieces, and the field thrown out by the cross bar disappears. On further rotation of the armature, as at D, the body of the core again becomes energized as the magnetic influence resumes its flow through it. These changes in the strength of the magnetic field when distorted by the armature core, as well as the intensity of the energy existing in the field, affect the windings and the electrical energy induced therein corresponds in strength to the rapidity with which these changes in magnetic flow occur. The most pronounced changes in the strength of the field will occur as the armature passes from position B to D, because the magnetic field existing around the core will be destroyed and again reëstablished.

During the most of the armature rotation the changes in strength will be slight and the currents induced in the wire correspondingly small; but at the instant the core becomes remagnetized, as the armature leaves position C, the current produced will be at its maximum, and it is necessary to so time the rotation of the armature that at this instant one of the cylinders is in condition to be fired. It is imperative that the armature be driven in such relation to the crankshaft that each production of maximum current coincides with the ignition point, this condition existing twice during each revolution of the armature, or at every 180 degrees travel. Each position shown corresponds to 45 degrees travel of the armature, or one-eighth of a turn, and it takes just one-half revolution to change the position from A to that shown at D. (See Fig. 10 also.)

Essential Parts of a Magneto and their Functions.—The magnets which produce the influence that in turn induces the electrical energy in the winding or loops of wire on the armature, and which may have any even number of opposed poles, are called field magnets. The loops of wire which are mounted upon a suitable drum and rotate in the field of magnetic influence in order to cut the lines of force is called an armature winding, while the core is the metal portion. The entire assembly is called the armature. The exposed ends of the magnets are called pole pieces and the arrangement used to collect the current is either a commutator or a col-

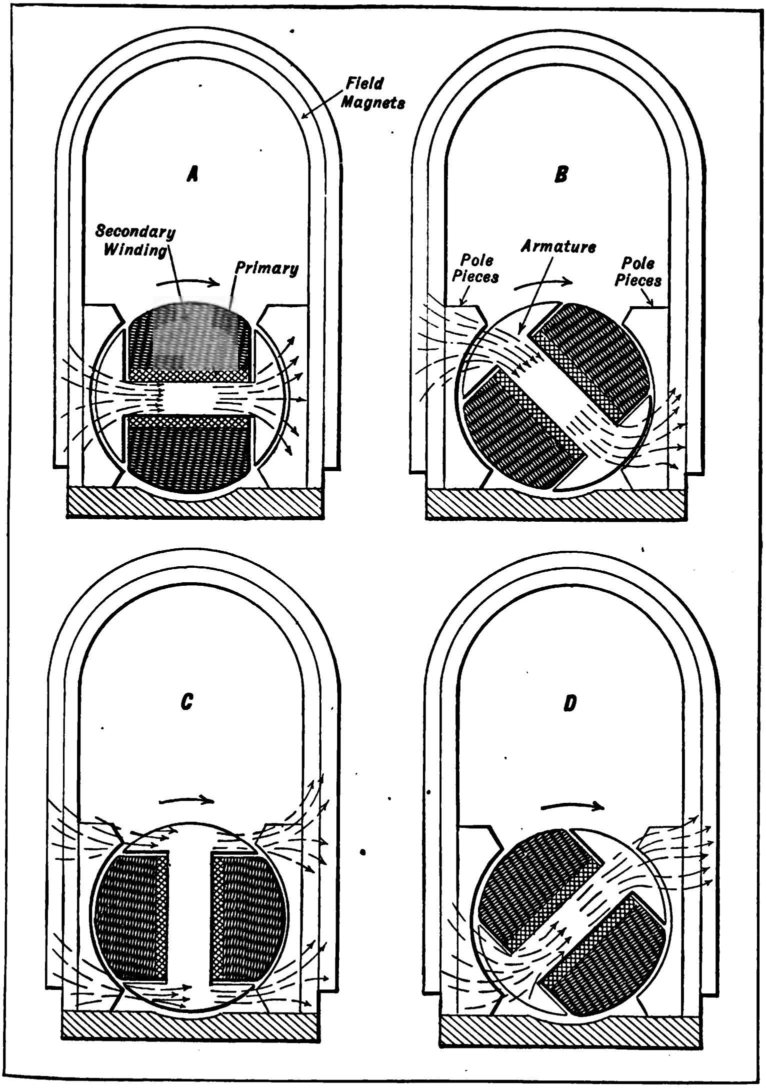


Fig. 9.—Showing How Strength of Magnetic Influence and of the Current Induced in the Windings of Magneto Armature Vary with the Rapidity of Changes of Direction in Flow.

lector. The stationary pieces which bear against the collector or commutator and act as terminals for the outside circuit are called brushes. These brushes are often of copper in large machines, or some of its alloys, because copper has a greater electrical conductivity than any other metal.

These brushes are nearly always made of carbon in small machines which is sometimes electroplated with copper to increase its electrical conductivity, though cylinders of copper wire gauze impregnated with graphite are often utilized. Carbon is used because it is not so liable to cut the metal of the commutator as might be the case if the contact was of the metal to metal type. The reason for this is that carbon has the peculiar property in that it materially assists in the lubrication of the commutator, and being of soft, unctuous composition, will wear and conform to any irregularities on the surface of the metal collector rings.

The magneto in common use consists of a number of horseshoe magnets which are compound in form and attached to suitable cast-iron pole pieces used to collect and concentrate the magnetic influence of the various magnets. Between these pole pieces an armature rotates. This is usually shaped like a shuttle, around which is wound coils of insulated wire. These are composed of a large number of turns and the current produced depends in great measure upon the size of the wire and the number of turns per coil. An armature winding of large wire will deliver a current of great amperage, but of small voltage. An armature wound with very fine wire will deliver a current of high voltage but of low amperage. In the ordinary form of magneto, such as used for ignition, the current is alternating in character and the break in the circuit should be timed to occur when the armature is at the point of its greatest potential or pressure. Where such a generator is designed for direct current production the ends of the winding are attached to the segments of a commutator, but where the instrument is designed to deliver an alternating current one end of the winding is fastened to an insulator ring on one end of the armature shaft and the other end is grounded on the frame of the machine.

The quantity of current depends upon the strength of the magnetic field and the number of lines of magnetic influence acting

through the armature. The electromotive force varies as to the length of the armature winding and the number of revolutions at which the armature is rotated.

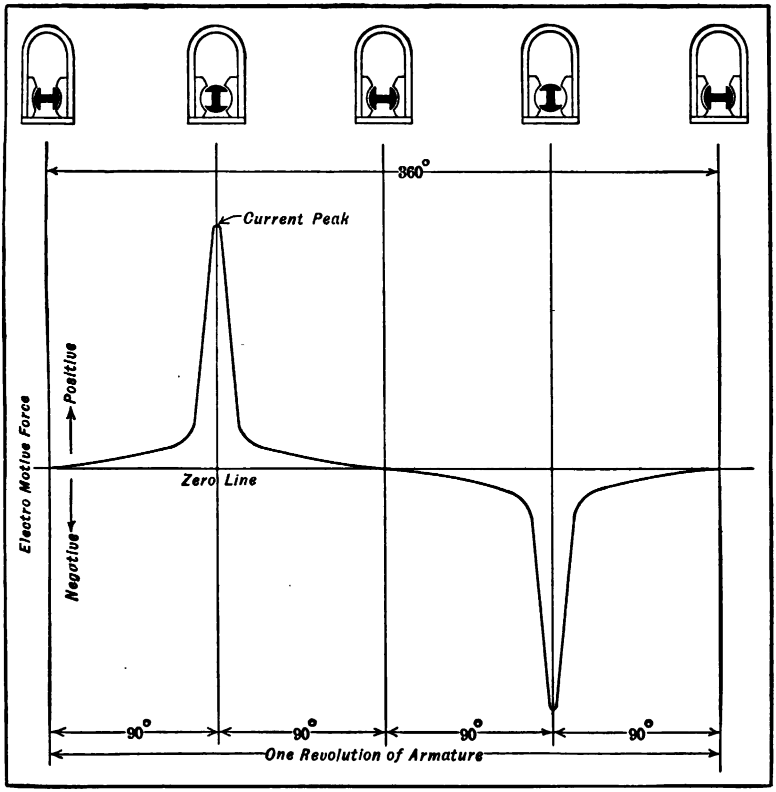


Fig. 10.—Diagram Showing How Magneto Current Strength Fluctuates with Varying Armature Positions

The Transformer System uses Low Voltage Magneto.—The magneto in the various systems which employ a transformer coil is very similar to a low-tension generator in general construction, and the current delivered at the terminals seldom exceeds 100 volts. As it requires many times that potential or pressure to leap the

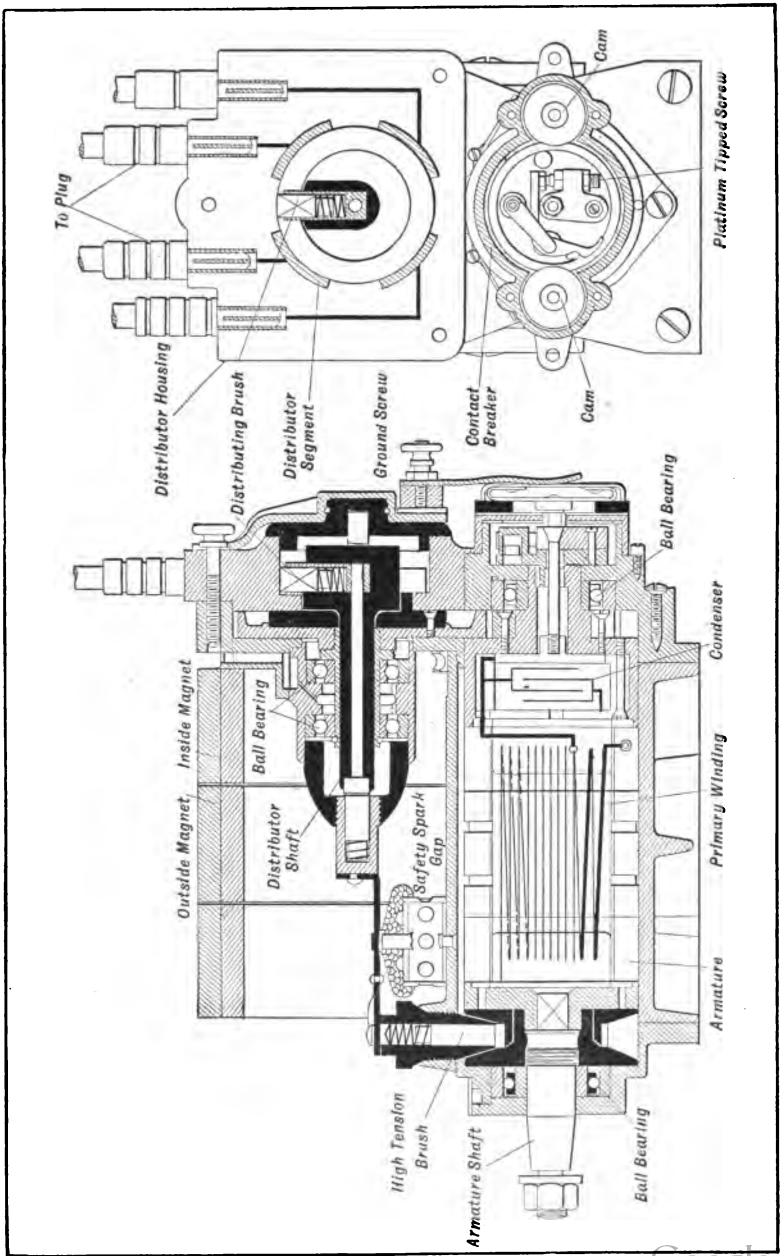


Fig. 11.—Side Sectional View of Bosch High Tension Magneto Showing Disposition of Parts. End Elevation Depicts Arrangement of Interrupter and Distributor Mechanism.

gap which exists between the points of the conventional spark plug, a separate coil is placed in circuit to intensify the current to one of greater capacity. The essential parts of such a system and their relation to each other are shown in diagrammatic form at Fig. 12. As is true of other systems the magnetic influence is produced by permanent steel magnets clamped to the cast-iron pole pieces between which the armature rotates. At the point of greatest potential in the armature winding the current is broken by the contact breaker, which is actuated by a cam, and a current of higher value is induced in the secondary winding of the transformer coil when the low voltage current is passed through the primary winding.

It will be noted that the points of the contact breaker are together except for the brief instant when separated by the action of the point of the cam upon the lever. It is obvious that the armature winding is short-circuited upon itself except when the contact points are separated. While the armature winding is thus short-circuited there will be practically no generation of current. When the points are separated there is a sudden flow of current through the primary winding of the transformer coil, inducing a secondary current in the other winding, which can be varied in strength by certain considerations in the preliminary design of the apparatus. This current of higher potential or voltage is conducted directly to the plug if the device is fitted to a single-cylinder engine, or to the distributor arm if fitted to a multiple-cylinder motor. The distributor consists of an insulator in which is placed a number of segments, one for each cylinder to be fired, and so spaced that the number of degrees between them correspond to the ignition points of the motor. A two-cylinder motor would have two segments, a three-cylinder, three segments, and so on within the capacity of the instrument. In the illustration a four-cylinder distributor is fitted, and the distributing arm is in contact with the segment corresponding to the cylinder about to be fired.

True High-Tension Magnetos are Self-Contained.—The true high-tension magneto differs from the preceding inasmuch as the current of high voltage is produced in the armature winding direct, without the use of the separate coil. Instead of but one coil, the armature carries two, one of comparatively coarse wire, the other

of many turns of finer wire. The arrangement of these windings can be readily ascertained by reference to the diagram B, Fig. 12, which shows the principle of operation very clearly. One end of the primary winding (coarse wire) is coupled or grounded to the armature core, and the other passes to the insulated part of the interrupter. While in some forms the interrupter or contact breaker mechanism does not revolve, the desired motion being imparted to the contact lever to separate the points by a revolving

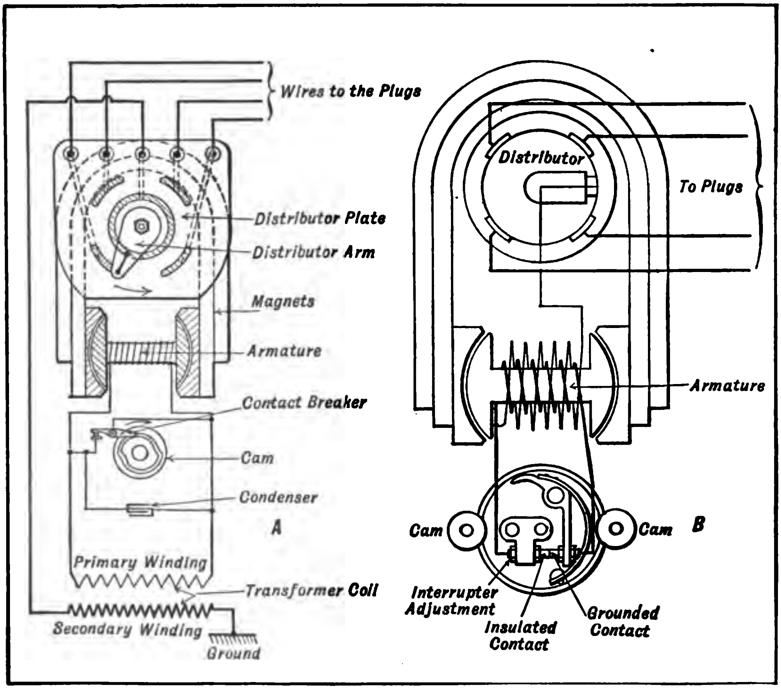


Fig. 12.—Diagrams Explaining Action of Low Tension or Transformer Coil Magneto System at A and True High Tension Magneto System at B.

cam, in this the cam or tripping mechanism is stationary and the contact breaker revolves. This arrangement makes it possible to conduct the current from the revolving primary coil to the inter-

rupter by a direct connection, eliminating the use of brushes, which would otherwise be necessary. In other forms of this appliance where the winding is stationary, the interrupter may be operated by a revolving cam, though, if desired, the use of a brush at this point will permit this construction with a revolving winding.

During the revolution of the armature the grounded lever makes and breaks contact with the insulated point, short-circuiting

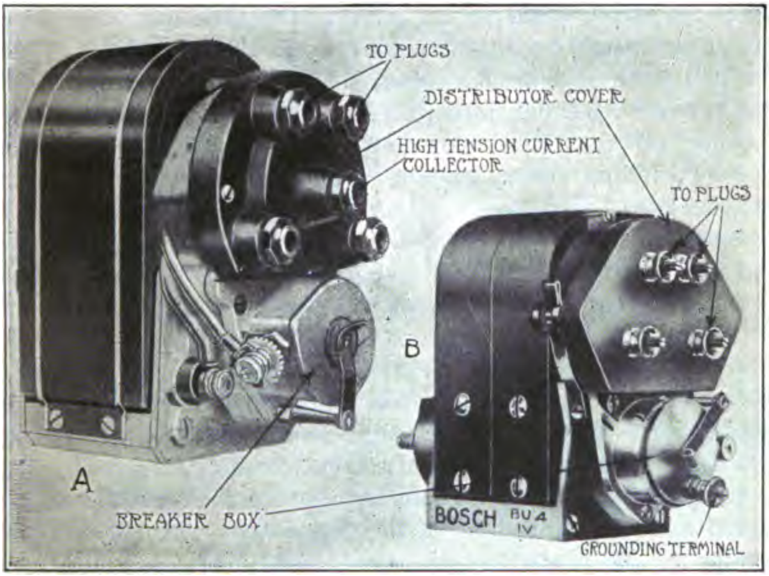


Fig. 13.—Typical Magneto Forms. A—Transformer Coil Type. B—True High Tension Instrument.

the primary winding upon itself until the armature reaches the proper position of maximum intensity of current production, at which time the circuit is broken, as in the former instance. One end of the secondary winding (fine wire) is grounded on the live end of the primary, the other end being attached to the revolving arm of the distributor mechanism. So long as a closed circuit is maintained feeble currents will pass through the primary winding, and so long as the contact points are together this condition will

exist. When the current reaches its maximum value, because of the armature being in the best position, the cam operates the interrupter and the points are separated, breaking the short circuit which has existed in the primary winding.

The secondary circuit has been open while the distributor arm has moved from one contact to another and there has been no flow of energy through this winding. While the electrical pressure will rise in this, even if the distributor arm contacted with one of the segments, there would be no spark at the plug until the contact points separated, because the current in the secondary winding would not be of sufficient strength. When the interrupter operates, however, the maximum primary current will be diverted from its short circuit and can flow to the ground only through the secondary winding and spark-plug circuit. The high pressure now existing in the secondary winding will be greatly increased by the sudden flow of primary current, and energy of high enough potential to successfully bridge the gap at the plug is thereby produced in the winding.

Dynamo Electric Machines.—Two distinct types of mechanical generators are in common use, and while their principles of action are practically the same, they differ somewhat in construction and application. The forms first used to succeed the battery were modifications of the larger dynamo electric machines used for delivering current for power and lighting. Later developments resulted in the simplification of the dynamo, by which it was made lighter and more efficient, and the modern magneto igniter is the form usually furnished on conventional power plants. A dynamo uses electro-magnets to produce a magnetic field for the armature to revolve in, and is necessarily somewhat heavier and larger than a magneto of equal capacity because the field in the latter instrument is produced by permanent magnets. An important advantage in using the magneto form of construction is that the weight of the windings is saved because the permanent magnets retain their magnetism and do not require the continual energizing that an electro-magnet demands.

The dynamo construction is superior where a continual drain is made upon the apparatus, because if a magneto is used continu-

ously the magnets are liable to lose some of their strength, and as the magnetic field existing between the pole pieces decreases in value the amount of current delivered by the apparatus diminishes in direct proportion. When electro-magnets are used the constant flow of electrical energy through the windings keeps them energized to the proper point, and as current is continuously supplied, the strength of the magneto field remains constant. The dynamo form of generator is utilized where currents of considerable value are needed, such as in electric lighting systems now so widely used on automobiles.

Where the device is depended upon only to furnish ignition current the magneto is preferred by most engineers because it is simpler and lighter than the dynamo, and also because it may be made in such form that it will comprise a complete ignition system in itself. When a dynamo is utilized the conditions are just the same, as far as necessary auxiliary apparatus is concerned, as though batteries were used, and one merely substitutes a mechanical generator in place of the chemical cells. The same auxiliary apparatus necessary in one case is employed in the other as well.

A dynamo or magneto produces electricity by an inductive action, which is a reversal of the phenomena by which a current of electricity flowing around a bar of iron or steel makes a magnet of it. If a wire through which a current of electricity is flowing will magnetize a bar of iron, a bar of steel which is already magnetized will generate a current of electricity by induction in a conductor surrounding it if either the magnet or the coil of wire is moved in such a manner that the magnetic influence is traversed or traverses the wire. In a dynamo or magneto a coil of wire mounted on a suitable armature is revolved between the pole pieces of the field magnet and as the conductor cuts across the zone of magnetic influence a current of electricity is induced in the coil. The faster the coil is rotated the more rapidly the winding passes through the magnetic field. As an electrical impulse is produced every time the magnetic field is traversed, it is patent that the greater number of electrical impulses will produce a current of higher value.

A sectional view of a typical governed dynamo electric machine

of simple design is shown at Fig. 14. All parts are clearly indicated and there should be no difficulty in understanding the principles of operation. The three main portions of the dynamo are the field magnets, which produce the magnetic field, the armature, which carries the coils of wire and which is mounted between the extremities or pole pieces of the magnet, and the brushes, which bear against segments of a collecting device known as a commutator serving to convey the current to terminals which are joined to the outer circuit. In the form shown the field magnets are

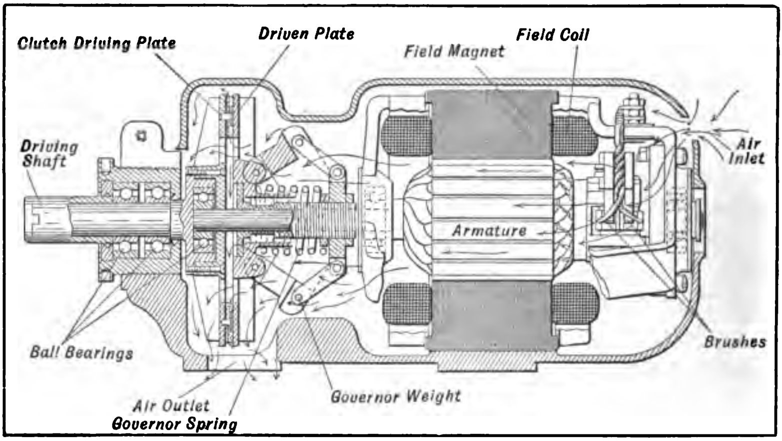


Fig. 14.—Gray & Davis Governed Dynamo, an Appliance for Producing Electricity by Mechanical Means.

composed of a number of iron stampings which are surrounded by a coil of wire, and two such magnets are provided, one above, the other below, the armature. The armature is supported on a shaft mounted in ball bearings so that it will turn with minimum friction. The whole mechanism is protected by an outer casing.

The device shown is a constant speed dynamo, i.e., it should be operated at a certain speed to obtain the best results. If run faster than the speed for which it is designed the excess current generated is liable to burn out the windings of the field magnet. For this reason a governor of the fly ball type is interposed between the

dynamo armature and the driving shaft coupled to the source of power. At all normal speeds the tension of the governor spring keeps the two plates of the clutch in contact and the armature is turned at the same speed as the driving shaft.

Should the driving shaft speed exceed a certain predetermined limit the governor weights will fly out by centrifugal force and the

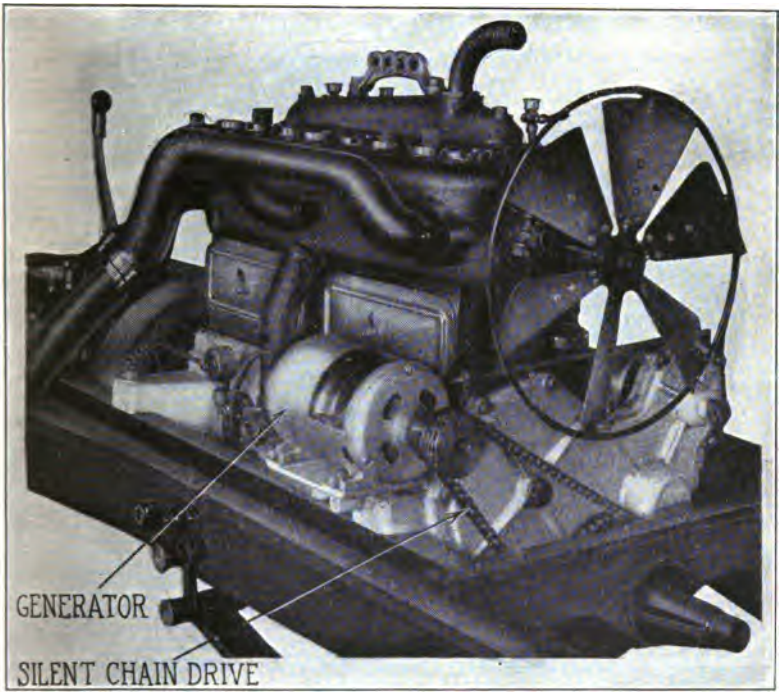


Fig. 15.—How Gray & Davis Generator is Driven by Silent Chain Connection with Engine Crankshaft.

governor spring will be compressed so the driving and driven plates of the clutch are separated and the driving shaft revolves independently of the armature. As soon as the armature speed becomes reduced sufficiently to allow the governor spring to overcome the centrifugal force and draw back the governor weights, the clutch

plates are again brought into contact and the armature is again joined to the driving shaft.

A current of air is kept circulating through the casing by means of the fan action of the reënforcing webs of the clutch plate, the object being to absorb any heat which may be produced while

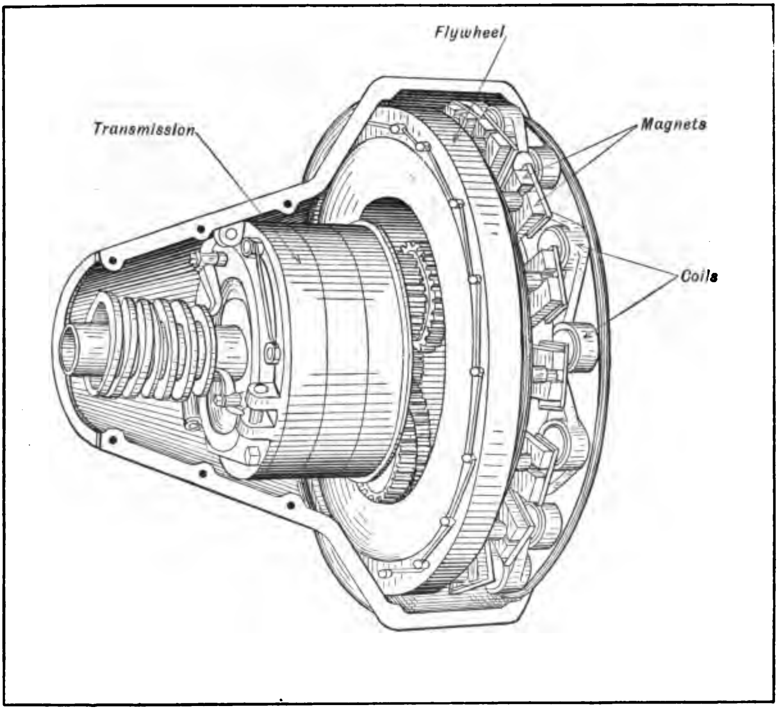


Fig. 16.—Distinctive Form of Current Producer Used on Ford Cars is Incorporated in the Power Plant Flywheel.

the dynamo is in action. An appliance of this nature may be driven from the engine by belt, chain, or gear connection (Fig. 15). It will deliver low voltage current which must be transformed by means of an inducction coil to current of higher value in order that it may be successfully utilized to produce the spark in the combustion chambers of the engine.

A very ingenious application of the dynamo is shown at Figs. 16 and 17. The electric generator is built in such a manner that it forms an integral part of the power plant. The magneto field is produced by a series of revolving magnets which are joined to and turn with the fly wheel of the motor. The armature coils are carried by a fixed plate which is attached to the engine base. This apparatus is really a magneto having a revolving field and a fixed armature, and as the magnets are driven from the fly wheel there is no driving connection to get out of order and cause trouble.

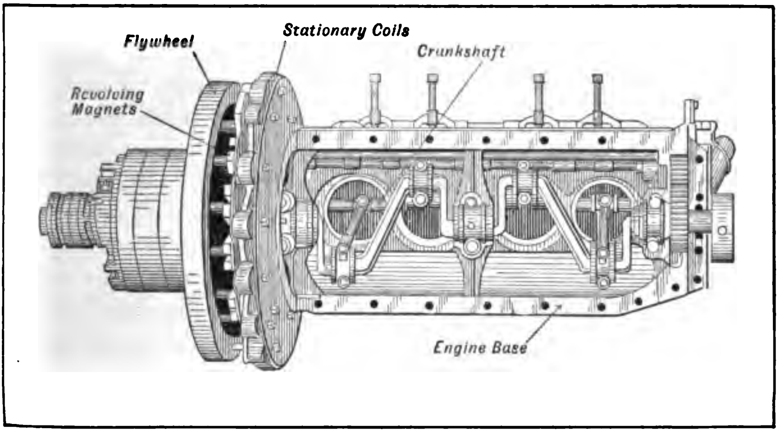


Fig. 17.—The Ford Magneto is Integral with Engine Base and Revolving Magnets are Attached to Flywheel Permitting Direct Drive from Crankshaft without Gears.

As the coils in which the current is generated are stationary, no commutator or brushes are needed to collect the current because the electricity may be easily taken from the fixed coils by direct connection. It has been advanced that this form of magneto is not as efficient as the conventional patterns, because more metal and wire are needed to produce the current required. As the magnets which form the heavier portion of the apparatus are joined to the fly wheel, which can be correspondingly lighter, this disadvantage is not one that can be considered seriously because the magnet weight is added to that of the motor fly wheel, the

combined weight of the two being that of an ordinary balance member used on any other engine of equal power.

Methods of Winding Dynamos.—The reader not versed in electrical science is apt to be puzzled by the designation of the various windings used on dynamos and motors. The armature windings and field coils may be connected together in a number of ways, as outlined at Fig. 18. The simple machine shown at A uses a permanent magnet to produce the field and therefore has only one set of windings to be considered, i. e., those on the armature. When the field magnet is an electro magnet another set of windings must be considered, i. e., those of the field magnet. When the current generated in the armature must first pass through the field windings before it reaches the external circuit the machine is said to be a series wound machine as shown at B because the armature and field windings are joined together in series. If only a portion of the current generated by the armature is directed to the field magnet windings the machine is said to be shunt wound, as shown at C. A compound wound dynamo is shown at D. In this two sets of field windings are used, one connected in shunt, the other coils in series. The shunt winding provides an initial excitation sufficient to generate full voltage at no load. The series coils provide an excitation that increases as the load increases and thereby strengthen the field so as to prevent the falling off in voltage that would otherwise occur. If the series coils are sufficiently powerful to make the voltage rise as the load increases the machine is said to be over-compounded.

The compound wound dynamo is the type used almost universally for direct current production. In stationary applications, compound wound motors are used where the load varies considerably under which conditions the extreme speed variation of series motors would be objectionable and where increased torque or turning power would be needed that shunt motors could not give. A compound wound dynamo is, to a certain extent, self-regulating, as the two coils counteract each other and bring about a more regular action for varying currents than that of the ordinary shunt or series wound dynamo. The extent of the regulation possible depends upon the proportions of the different windings though a compound

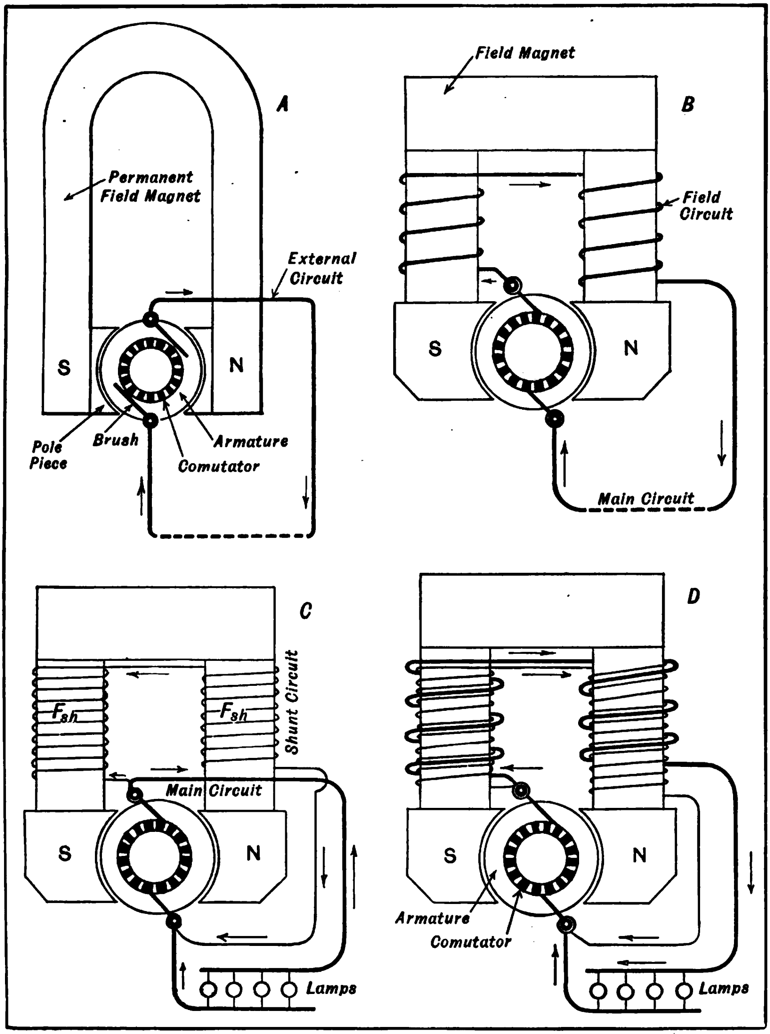


Fig. 18.—Diagram Showing Methods of Winding Dynamo. A—Simple Magneto Generator. B—Series Wound Machine. C—Shunt Wound Machine. D—Compound Type.

wound machine can be self-regulating at only one particular rotative speed. In a series wound dynamo short circuiting or lowering the resistance of the external circuit strengthens the field, thereby increasing the electro-motive force and the current strength. Some cut out means are usually provided to break the external circuit or to interpose added resistance to keep the current strength relatively constant and prevent injury to the windings by heating of the wire and melting of the insulation. In a shunt wound dynamo the lowering of resistance on the outer circuit takes current from the field and lowers the electro motive force of the machine. Short circuiting has no heating effects. A compound wound machine combines, to a certain degree, the features of both the shunt and series wound dynamo. In a dynamo where the armature windings are grouped in coils which have independent terminals and which are not connected in series, the construction is termed "open coil." The terminals are attached to separate divisions of the commutator and are so spaced that the collecting brushes touch each pair belonging to the same coil simultaneously. The brushes therefore take current from only one coil at a time. In a closed coil dynamo, the armature windings are connected in series and current is delivered from all coils.

Electrical Terms Defined.—In referring to any force it is necessary to have some units by which its capacity may be judged. For instance, in comparing bodies of different size we can use units which will show the difference of mass or dimensions, such as pounds or feet, or the fractions and multiples thereof. To gauge the ability of the electric force there are several practical units with which all motorists should be familiar. They are the volt, watt, ohm and ampere.

The VOLT is the practical unit of electro-motive force, pressure, or difference of potential or condition, existing between different parts of the circuit. Referring again to the reservoirs of water, we would find a foot height of liquid a very convenient expression to use as a difference of height or head of water, and such is in constant use by all engineers. This is a precise analogy to the volt which is the unit that measures the tendency of an electric charge to escape to the opposite level, this being the actuating force

of currents. The volt is the cause of the current, not a part of it. It is the difference in voltage which causes a current to flow from one object to another. The expression 100 or any other number of volts current has no foundation; the expression should be, 100-

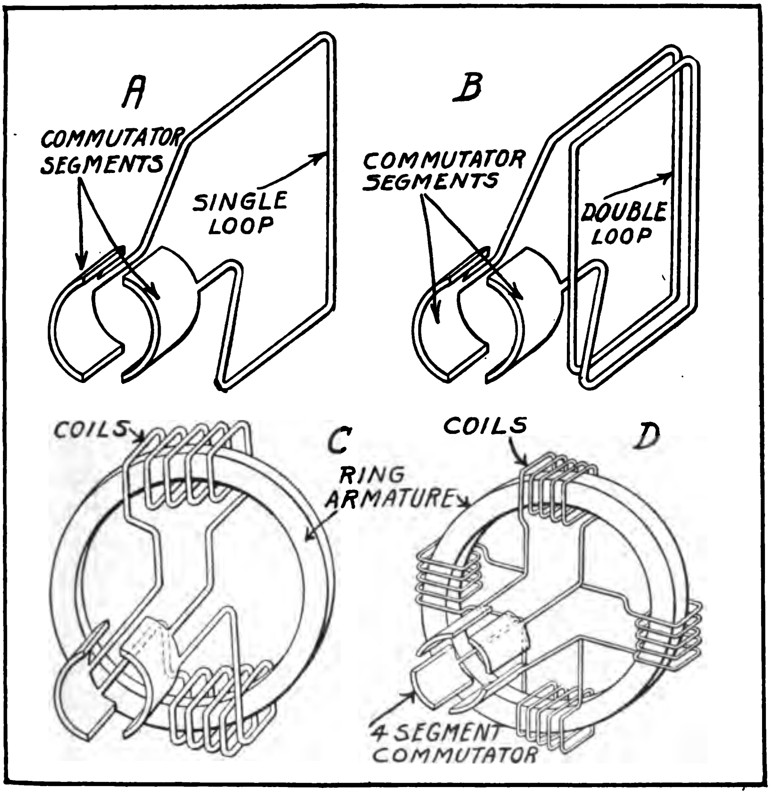


Fig. 19.—Simplified Diagram Showing How Direct Current Generator Armatures are Wound.

volt circuit. The familiar dry cell maintains a difference of about one and one-quarter volts between the surfaces of the elements of which it is composed.

The OHM is the unit by which resistance is judged. Everything has electrical resistance. Some elements have very little,

such as a short length of a good conductor; others have so much as to form a most effectual barrier to the passage of the current, these being commonly known as insulators. As an example, consider a man lifting weights. The heavier the weight, the harder he must work to lift it. A little body weighing a few ounces offers so little resistance that it can be raised from the ground with a negligible amount of work. At the other hand it may have a mass

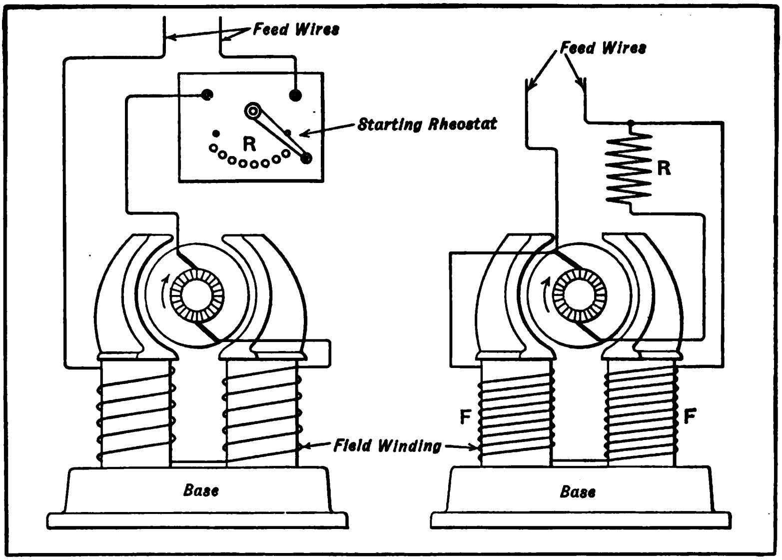


Fig. 20.—Diagram Showing Electric Motor Windings. At Left—Series Wound. At Right—Shunt Wound.

of several tons, in which case enough resistance would be offered to make it immovable against the efforts of one man, though a number of men might easily move it without mechanical aid.

A substance that would offer considerable resistance to a current of low-tension or voltage would be easily overcome by a current having greater electro-motive force. For instance, it is impossible to pass the current obtained, from several cells of dry battery through the air gap between the points of a plug, as the current

pressure, only a few volts, is not sufficient to overcome the resistance offered by the air between the electrodes. At the other hand, pass this same battery current through a transformer, such as an induction coil, and it produces another current of greater potential and at high enough voltage to overcome the resistance of the air gap. As an example a column of mercury one square millimeter in cross section and 1.0624 meters long has the resistance of one ohm.

The unit of current strength or intensity is the *AMPERE.* Take a conductor of one ohm resistance, maintain a difference of potential of one volt between the ends, and in one second a quantity of current equal to one ampere would have passed through it. A greater voltage will maintain a greater current flow through the same resistance, or a greater resistance will reduce the current in exact proportion. For example, two volts would pass two amperes through one ohm resistance but would only pass one ampere through two ohms resistance. The ampere is really a unit denoting the rate of flow, and is exactly analogous to a well-known unit used in hydraulics, known as the "miner's inch." This denotes the rate of flow of water which, under a head of six inches, will pass through a hole one inch square in a board two inches thick. Let this head of water represent one volt, and let the resistance of the hole represent one ohm, then the "miner's inch" would represent a current of an ampere.

A *WATT* is a unit of quantity, or amount of electric energy, and corresponds to a current of one ampere at a pressure of one volt. There are other terms in which a unit of time is compounded with the foregoing, such as *ampere-hour,* which means that a generator of certain capacity could maintain a current of one ampere for one hour. It is a term usually applied to determine the capacity of a chemical producer. For instance, a storage battery with 60 ampere-hours capacity should supply, theoretically, a current of one ampere for 60 hours, two amperes for 30 hours or 60 amperes for one hour, or any other combination of time and amperes which would produce the same result. Electrical rate of work is measured by a unit involving potential difference, quantity of electricity and time. Thus a watt is a volt-ampere-second, and 746

watts indicate an amount of electrical energy equal to one mechanical horsepower.

Electrical Measuring Instruments.—As the electric force is intangible and is known only by its effects, it is necessary to have methods of measuring the amount employed to properly use the current. If the current was too strong injurious results might follow and if not strong enough satisfactory results could not be secured. The electric force can be measured by relatively simple devices. Most of the electrical measuring instruments depend upon the principle of electro-magnetism or induction and may be classified as moving iron, moving coil, solenoid and plunger, magnetic vane, hot wire, inclined coil, etc. The four first named are the most commonly used in measuring the current employed in starting and lighting systems. These measuring instruments are made in portable and switchboard types. The windings in an instrument designed to measure current quantity or amperage is usually of coarse wires, while the windings of an instrument to measure electro motive force or voltage will be of finer wire. The gauge used to measure current quantity is called an ampere meter or ammeter while that used to measure current pressure is a volt meter.

The various forms of electrical measuring instruments and the method of operation may be readily understood by referring to the illustrations at Fig. 21. The instrument shown at A is known as a moving iron type. In this a permanent magnet holds a soft iron indicator to which the pointer needle is attached so that it registers with zero on the scale until a current passes through the coil and the magnetic lines of force thus produced tend to pull the needle in line with them and thereby actuate the pointer. The movement of the soft iron indicator depends entirely upon the amount of current passing through the coil. The moving coil pipe which is shown at B is the most popular form, as it gives the most reliable indication. The parts of a complete instrument of this form are clearly outlined at Fig. 22. This consists of a permanent magnet carrying a fixed pole piece about which a small solenoid capable of oscillating back and forth on jeweled bearings is mounted. On the cheap instruments ordinary pivot bearings are used instead of the jewels. A hand or pointer is pivoted at the

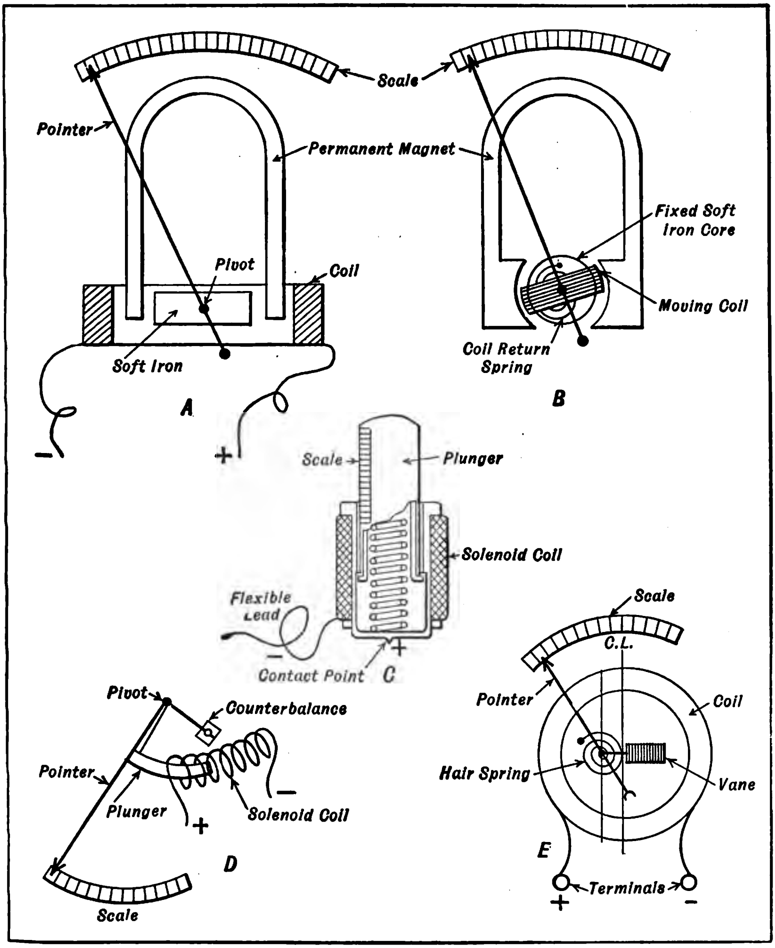


Fig. 21.—Diagrams Outlining Construction of Common Types of Current Indicators.

bearing and moves with the coil to indicate the variations of current strength on a graduated scale with which the pointer registers. A steel hair spring attached to the coil acts to restrain and control its movements and to return the pointer to zero when the current

ceases to flow through the solenoid. The function of the magnetic field is to keep the solenoid steady, though as soon as an electric current passes through its equilibrium is upset and the degree of movement is proportional to the amount or pressure of the current passing through it. Many small instruments which are accurate and inexpensive have been devised for testing current strength.

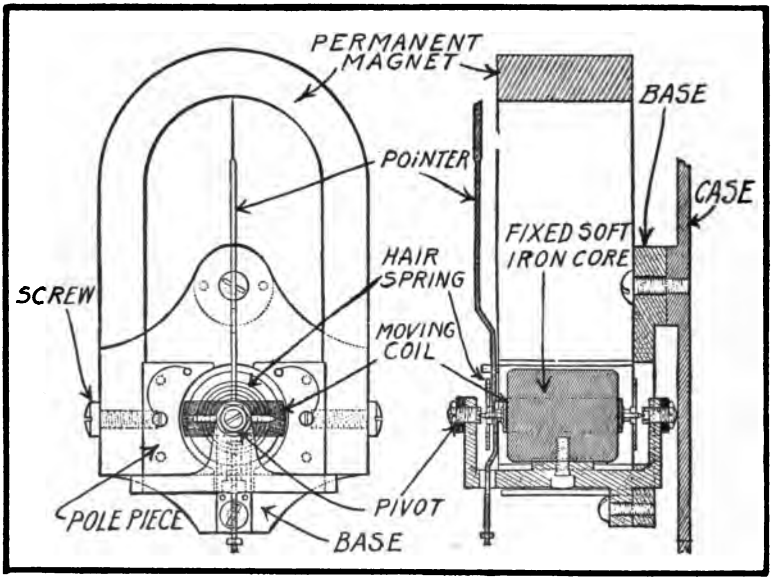


Fig. 22.—Diagram Showing Construction of Moving Coil Type Voltmeter.

For convenience the mechanism has been enclosed in standard watch movement cases in many instances.

The plunger type of indicator which is shown at C and D operates on the principle of attraction that a solenoid exerts upon materials susceptible to its influence. A curved plunger is used in that type usually intended for switch-board use. When a current is passed through the solenoid, the plunger is drawn into the interior of the coil, the amount of movement depending upon the current strength. This is indicated by a calibrated scale and

pointer. The small battery tester which is very simple in construction works on exactly the same principle, except that the vertical plunger which is drawn into the solenoid has the scale indicated upon it. The solenoid is kept pressed out against a stop by spring pressure which is overcome as soon as the current passes through the winding. The plunger type is not reliable for very small readings and is readily affected by any magnetic field in the vicinity.

The instrument shown at E is a magnetic vane type. In this a vane of soft iron is supported eccentrically or off center and when a current passes through the surrounding coil the vane is attracted toward the position where it will conduct the greatest number of lines of force, this movement actuates the pointer attached to the vane support and a hair spring is used as in other instruments to return the pointer to zero when the current flow ceases and also to steady the action of the instrument. The small amperemeters are used only for testing dry cells, as the scale reads only to 30 amperes. This form of instrument is also used as an indicator to show the rate of charge of a storage battery by the generator or current consumption of the lamps of the lighting system. The ordinary form of ammeter should never be used for testing storage cells and a voltmeter is necessary for this purpose. Sometimes an amperemeter is so constructed with an internal resistance that can be put in series with the solenoid coil that it will read voltage on another scale. An instrument that

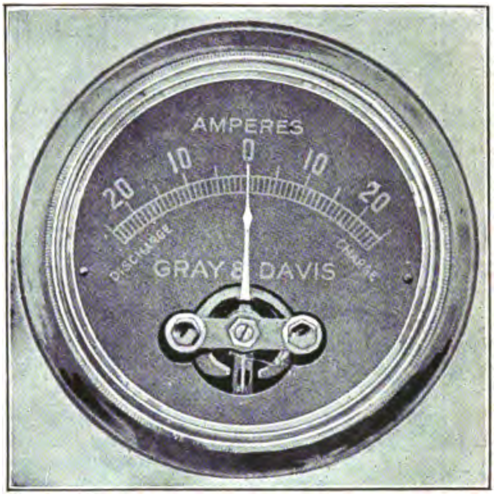


Fig. 23.—Typical Dash Type Amperemeter Used with Modern Lighting System.

+	POSITIVE, SOMETIMES ABBREVIATED "P"				
—	NEGATIVE, SOMETIMES ABBREVIATED "N"				
→	ARROW INDICATES DIRECTION OF CURRENT FLOW.				
OR C.W.	CLOCKWISE REVOLUTION.	P	PRIMARY.		
OR C.C.W.	COUNTER-CLOCKWISE REVOLUTION.				
	COIL OF INSULATED WIRE. (COARSE.)				
	COIL OF INSULATED WIRE. (FINE.)				
A	AMMETER.		PUSH BUTTON OR LIGHTING SWITCH.		
V	VOLTMETER.		STARTING SWITCH.		
	SHUNT WOUND MACHINE MOTOR OR GENERATOR.		MOTOR-GENERATOR 3-TERMINAL.		
	SERIES WOUND MACHINE MOTOR OR GENERATOR.		MOTOR-GENERATOR 4-TERMINAL.		
G	GENERATOR.	C	CARBON OF DRY BATTERY.		
M	MOTOR.	Z	ZINC OF DRY BATTERY.		
	WIRES JOINED TOGETHER, SAME CIRCUIT.				
	WIRES CROSSING, SEPARATE CIRCUITS.				
	RHEOSTAT OR VARIABLE RESISTANCE.				
	INCANDESCENT LAMP.	S	SECONDARY.		
	DRY CELLS OR STORAGE BATTERY. CELLS IN SERIES.				
V	VOLT, UNIT OF POTENTIAL OR PRESSURE.				
A	AMPERE, UNIT OF CURRENT QUANTITY.				
D. C.	DIRECT CURRENT, FLOWS CONTINUOULY AND ALWAYS IN ONE DIRECTION.				
A. C.	ALTERNATING CURRENT, FLOWS FIRST IN ONE DIRECTION THEN THE OTHER.				
K. W.	KILOWATT. (1,000 WATTS).				
H. P.	HORSE POWER. (746 WATTS).				
W	WATT = ONE VOLT X ONE AMPERE.				
	GROUND CONNECTION.		HEAVY CABLE.		
	FUSE.		BALLAST COIL.		
	PUSH BUTTON.		COWL LIGHT.		AUTOMATIC CUT-OUT.

Fig. 24.—Index to Signs, Symbols and Abbreviations Used in Wiring Diagrams.

will indicate 30 amperes and register up to eight volts has a range that is ample for all practical purposes. Some very low reading ammeters were formerly sold extensively as coil current consumption indicators, but with the passing of the vibrator coil ignition system they are no longer used to any extent.

CHAPTER II

BATTERY AND COIL IGNITION METHODS

How Compressed Gas May Be Ignited—Methods of Electric Ignition—Parts of Simple Ignition System—Induction Coil Action—Timers and Distributors—Spark Plugs—Individual Coil System—Vibrator-Distributor Systems—Master Vibrator Systems—Non-Vibrator Distributor System—Low Tension Ignition—Double and Triple Ignition Systems—Battery Ignition System Troubles—Charging Storage Batteries—Care and Repair of Spark Plug Faults—Induction Coil—Timers—Wiring Troubles and Electro-static Effects—Timing Battery Ignition System.

How Compressed Gas May Be Ignited.—One of the most important auxiliary groups of the gasoline engine comprising the automobile power plant and one absolutely necessary to insure engine action is the ignition system or the method employed of kindling the compressed gas in the cylinder to produce an explosion and useful power. The ignition system has been fully as well developed as other parts of the automobile, and at the present time practically all ignition systems follow principles which have become standard through wide acceptance.

During the early stages of development of the automobile various methods of exploding the charge of combustible gas in the cylinder were employed. On some of the earliest engines a flame burned close to the cylinder head and at the proper time for ignition, a slide or valve moved to provide an opening which permitted the flame to ignite the gas back of the piston. This system was practical only in the primitive form of gas engines in which the charge was not compressed before ignition. Later, when it was found desirable to compress the gas a certain degree before exploding it, an incandescent platinum tube in the combustion chamber, which was kept in a heated condition by a flame burning in it, exploded the gas. The naked flame was not suitable in this appli-

cation because when the slide was opened to provide communication between the flame and the gas the compressed charge escaped from the cylinder with enough pressure to blow out the flame at times and thus cause irregular ignition. When the flame was housed in a platinum tube it was protected from the direct action of the gas, and as long as the tube was maintained at the proper point of incandescence regular ignition was obtained.

Some engineers utilized the property of gases firing themselves if compressed to a sufficient degree, while others depended upon the heat stored in the cylinder head to fire the highly compressed gas. None of these methods were practical in their application to motor car engines because they did not permit flexible engine action which is so desirable. At the present time, electrical ignition systems in which the compressed gas is exploded by the heating value of the minute electric arc or spark in the cylinder are standard, and the general practice seems to be toward the use of mechanical producers of electricity rather than chemical batteries used alone.

Methods of Electrical Ignition.—Two general forms of electrical ignition systems may be used, the most popular being that in which a current of electricity under high tension is made to leap a gap or air space between the points of the sparking plug screwed into the cylinder. The other form, which has been almost entirely abandoned in automobile practice, but which is still used to some extent on marine engines, is called the low-tension system because current of low voltage is used and the spark is produced by moving electrodes in the combustion chamber.

The essential elements of any electrical ignition system, either high or low tension, are: First, a simple and practical method of current production; second, suitable timing apparatus to cause the spark to occur at the right point in the cycle of engine action; third, suitable wiring and other apparatus to convey the current produced by the generator to the sparking member in the cylinder.

The various appliances necessary to secure prompt ignition of the compressed gases should be described in some detail because of the importance of the ignition system. It is patent that the scope of a work of this character does not permit one to go fully into the theory and principles of operation of all appliances which

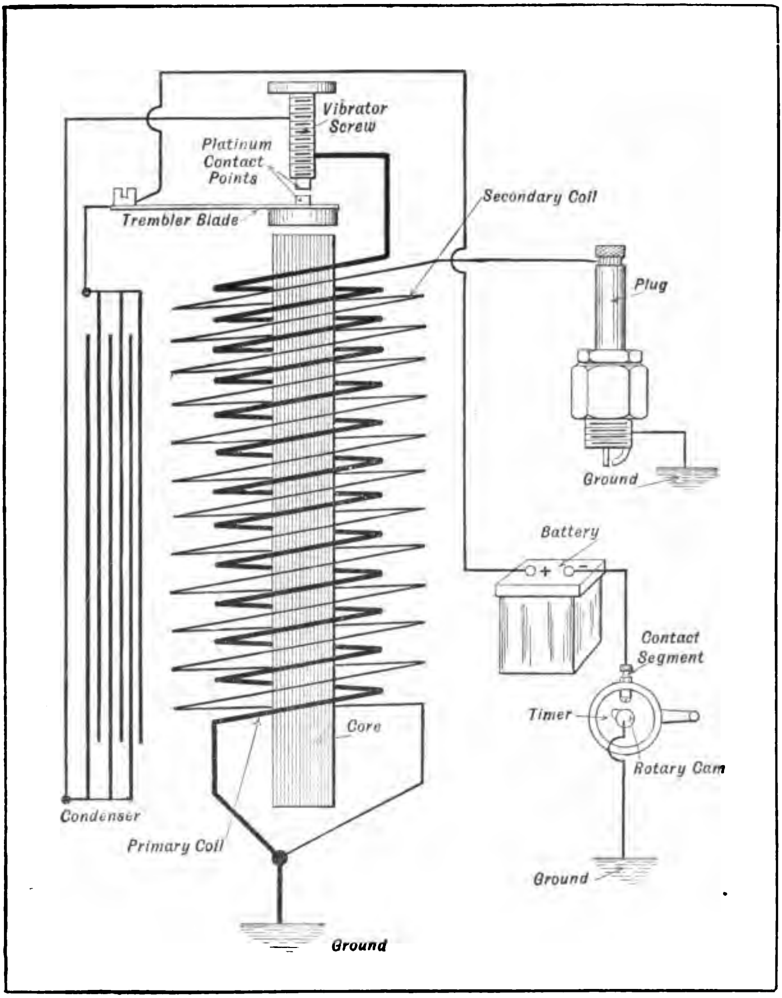


Fig. 25.—Simple Battery Ignition System for One-Cylinder Motor Showing Important Components and Their Relation to Each Other.

may be used in connection with gasoline motor ignition, but at the same time it is important that the elementary principles be considered to some extent in order that the reader should have a proper

understanding of the very essential ignition apparatus. The first point considered has been the common methods of generating the electricity, then the appliances to utilize it and produce the required spark in the cylinder.

Essential Elements of Simple Ignition System.—The current obtained from the dry or storage battery or low-tension dynamo or magneto is not sufficiently powerful to leap the gap which exists between the points of the spark plug in the cylinder unless it is transformed to a current having a higher potential. The air gap between the points of the spark plug has a resistance which requires several thousand volts pressure to overcome, and as a battery will only deliver six to eight volts, it will be evident that, unless the current value is increased, it could not produce a spark between the plug electrodes.

The low voltage current is transformed to one of higher potential by means of a device known as the induction coil. The current from the battery is passed through the primary coil, which is composed of several layers of coarse wire wound around a core of soft iron wire to form an electro-magnet as shown at Fig. 25. Surrounding this primary coil is one composed of a large number of turns of finer conductor. When a current of electricity of low voltage passes through the primary coil, a current of very high electro-motive force is produced in the secondary winding. One end of each coil is grounded. The free end of the primary coil is coupled to the battery while that of the secondary coil is attached to the insulated terminal of the spark plug.

The arrangement of wiring at Fig. 25 is that employed in a typical transformer coil which is used to increase the voltage of the current sufficiently to cause it to overcome the resistance of the air gap at the spark plug and produce a spark which will ignite the gas. In the primary circuit are included a suitable timer for closing the circuit, a battery of chemical cells to supply the energizing current, and a vibrator or make-and-break mechanism on the coil. The secondary circuit includes the spark plug and the secondary winding of the coil.

When the primary circuit is closed by the cam of the timer making contact with the segment, the current from the battery flows

through the primary coil of the transformer. This magnetizes the core which draws down the trembler blade, this in turn separating the platinum contact point of the vibrator and interrupting the current. As soon as the current is interrupted at the vibrator the core ceases to be a magnet and the trembler blade flies back and once again closes the circuit between the platinum points. Every time the circuit is made and broken at the vibrator an electrical impulse is induced in the secondary winding of the coil.

The vibrator may be adjusted so that it will make and break the circuit many times a minute and as a current of high potential is produced in the secondary winding with each impulse, a small spark will be produced between the points of the spark plug. The condenser is a device composed of layers of tin foil separated from each other by waxed or varnished paper insulation. It is utilized to absorb some of the excess current produced between the vibrator points, which causes sparking. This extra current is induced by the action of the primary coils of wire upon each other and by a reversed induction influence from the secondary coil.

If this current is not taken care of, it will impede the passage of the primary current and the sparks are apt to burn or pit the platinum contact points of the vibrator. When a condenser is provided the extra primary current is absorbed by the sheets of tin foil which become charged with electricity. When contact is made again the condenser discharges the current in the same direction as that flowing through the primary coil from the battery and the value of the latter is increased proportionately. There is less sparking between the vibrator points and a stronger current is induced in the secondary coil which in turn produces a more intense spark between the points of the spark plug.

A typical induction coil such as would be used for firing a one-cylinder engine if used with a simple timer, or a multiple-cylinder engine if used in connection with a combined timer and distributor, is depicted in part section at Fig. 26. It will be observed that three terminal screws are provided on the box, one designed to be attached to the battery, the other two to the spark plug and ground, respectively. The terminal to which the battery wire is attached is coupled to the bridge member which carries the contact screw while

the vibrator blade is connected with one of the ends of the primary coil. The other end of the primary coil goes to the terminal which is joined to the ground. The condenser is shunted in between the vibrator points, i. e., one of the leads is attached to terminal No. 1 while the other is soldered to the end of the primary coil which goes on the vibrator spring member. One end of the secondary coil is attached to terminal No. 2, which is grounded on some metal

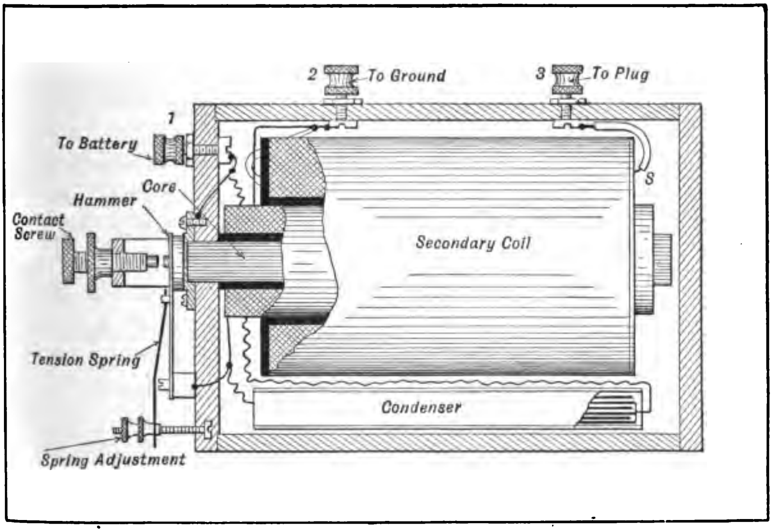


Fig. 26.—Part Sectional View of Simple Induction Coil, an Important Component of All Battery Ignition Groups and Sometimes Used with Magnetos.

part of the chassis frame, while the other end is secured to terminal No. 3, which is joined to the spark plug electrode. After the various components of the induction coil are assembled in the box and the connections made as indicated, the spaces between the sides of the box and the coil member are filled with an insulating compound composed of bees-wax, pitch and rosin. This holds everything rigidly in place and prevents the wire joints loosening through vibration. The external appearance of a one-cylinder box coil of the vibrator type is shown at Fig. 27.

The method of connecting the members of an induction coil,

shown at Fig. 26, is a conventional one, though the connections will differ with the nature of the circuit of which the coil forms a part and the number of units comprising the coil assembly. When such devices are employed for igniting multiple-cylinder motors, the internal wiring is very much the same as though the same number of box coils for single-cylinder ignition were combined together by outside conductors. The number of terminals provided will vary with the number of units.

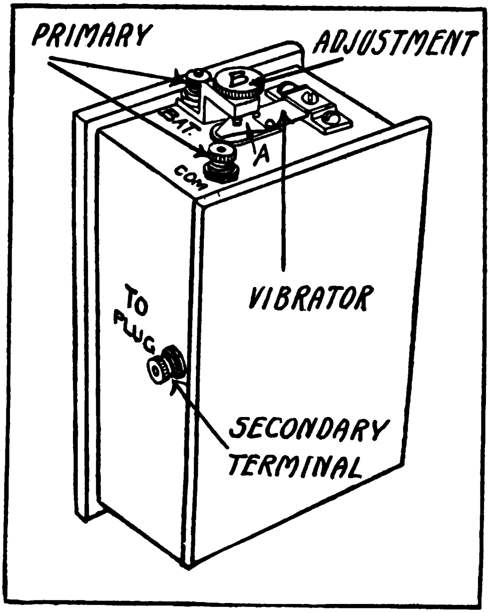


Fig. 27.—Three Terminal Box Coil for Single Cylinder Engine Ignition.

Various forms of induction coils are depicted at Fig. 28. That at A is a simple unit form in which the coil is attached directly to the spark plug, which in turn is screwed into the cylinder. On this coil but two primary terminals are attached, one being connected to the insulated contact point on the timer, the other being grounded, or attached to the battery. Coils of this type have been very popular in marine application because of the simple and direct wiring possible, but they have not been used in connection with automobile engine ignition to any extent. The form shown at B is a simple dash coil for one-cylinder use which has three terminals, one being used for a secondary lead to the spark plug, the other two being joined to the battery and ground respectively, as shown at Fig. 26.

The form of coil shown at C is a two-unit member designed for double-cylinder ignition. As the switch is mounted on the coil box

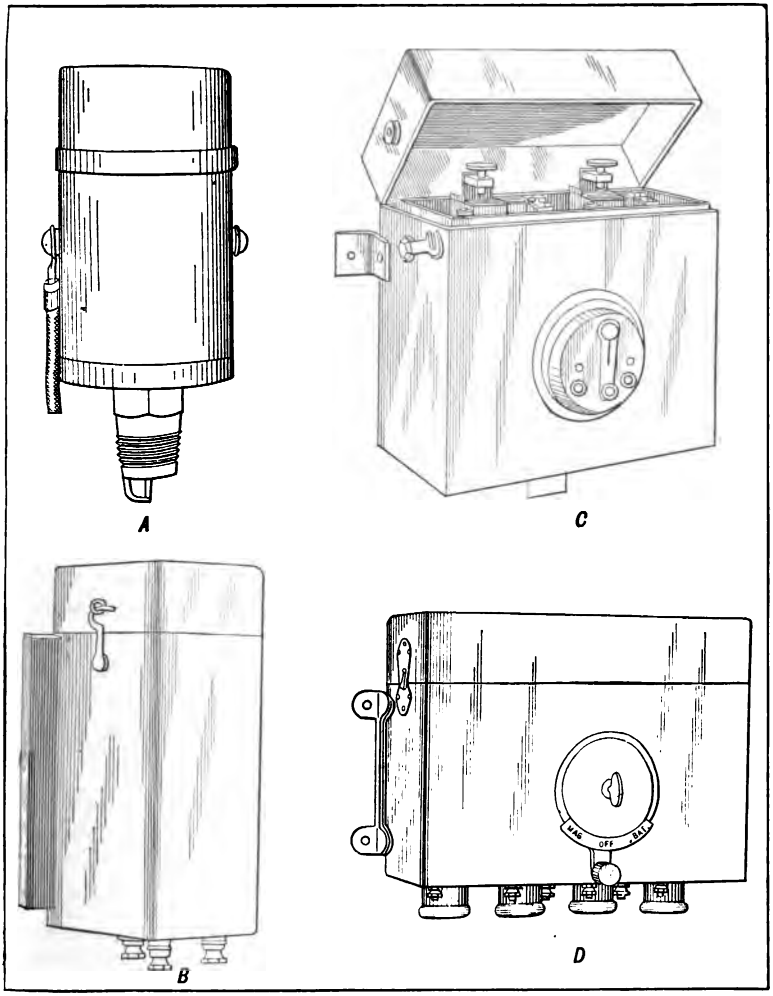


Fig. 28.—Conventional Induction Coil Forms. A—Coil Unit and Plug Combined. B—Simple Dash Coil for One Cylinder Ignition. C—Two Unit Coil for Two Cylinder Motor. D—Four Unit Coil for Four Cylinder Service.

to use two sets of batteries, six terminals are provided on the bottom of the coil case. Two of these are attached directly to the insulated contact point of the timer; two others which are enclosed in hard rubber insulating caps are attached to the spark plugs. The two immediately under the switch are attached to the free terminals of the battery, two sets being provided, one being coupled to each side of the switch.

With a four-unit coil, as shown at D, ten terminals are provided because of the attached switch. Four go to the spark plugs, four to the insulated segments of the timer and two to the battery, or battery and magneto or dynamo, as the case may be. In modern coils the units may be removed from the box without disturbing any internal connection, and a new one slipped in its place if it does not function properly. Special care is taken in insulating the high-tension terminal by means of rubber caps which surround the wire, and care is taken to have the vibrator contact points readily accessible for inspection, cleaning, or adjustment.

Action of High Tension Coil Ignition System.—Another explanation of the action of the conventional induction coil and battery system may enable the reader to obtain a clearer understanding of the action of the transformer coil system of intensifying current and can be read to advantage to supplement the explanation previously given. Another diagram, Fig. 29, shows a four terminal coil unit instead of the three terminal coil diagram outlined at Fig. 25, and differs in that the primary and secondary circuits have separate ground connections instead of having a common terminal on the coil. As the internal construction of the induction coil has been previously described, it will be merely necessary to review the action of the complete ignition system outlined.

In the diagram shown the action is as follows: When the switch E is closed and the rotor (f) of the spark-timing device D comes in contact with the terminal (g), the current flows from the positive terminal (m) of the battery to the switch E. From thence to the primary terminal (h) on the coil; and through the vibrator spring (e) across the points (o) which are in contact, to the adjusting screw (i) and into the bridge which supports the adjusting screw. The primary winding (b) is attached to this bridge at (j) and

the current flows through it to the terminal (k), from which terminal it is carried to the point (g) on the commutator and into the rotor (f). A metal brush takes up the current at this point and it is carried to the negative terminal (n) of the battery, passing through the battery it reaches the point (m) from which it started. The current will not flow unless the circuit is complete,

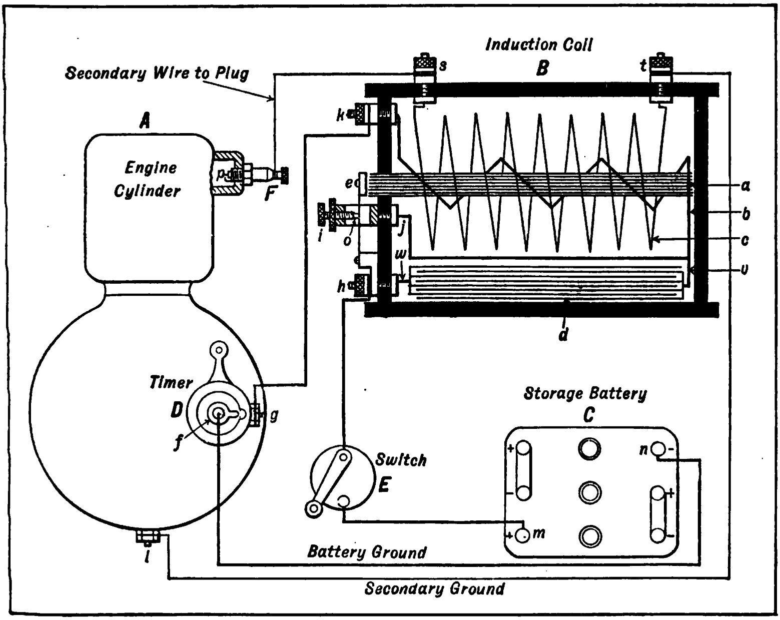


Fig. 29.—Typical Simple Battery Ignition Group for One Cylinder Motor Using Four Terminal Induction Coil.

and it cannot be complete unless the rotor (f) touches the terminal (g). This rotor is so set on the engine and so timed in relation to the movement of the piston that it will complete the circuit only at the time the spark is desired in the cylinder. When the current flows through the primary winding it makes a magnet of the core and enables it to attract the armature, as a magnet will attract pieces of iron or steel, and the armature is made of magnetic material.

The vibrator is composed of a piece of spring steel with a small iron button riveted to the end of it. When the circuit is complete and the core is magnetized it attracts the iron button and breaks the contact of the points at (o), thus interrupting or opening the circuit and preventing further flow of the current. The core then loses its magnetism and the vibrator spring pulls the button back and again brings the points in contact to again complete the circuit. This occurs about one hundred times per second and the rapid vibration produces a pronounced buzzing sound at the vibrator.

When the points (o) are in contact and the core is magnetized a very strong magnetic field flows across the wire of the secondary winding (c). When the field becomes strong enough to attract the vibrator button the circuit is broken and the current stops flowing. As soon as the current ceases to flow and the magnetic field or force becomes reduced in intensity, a strong or high voltage current is produced in the secondary winding. This current flows to the spark plug F from the secondary terminal of the coil (s) and it has sufficient power to jump the air gap at (p), causing a spark. The spark plug construction is such that after jumping the air gap the secondary current will flow back to the engine and from the ground terminal (l) to the terminal (t) and then back through the secondary winding to the terminal (s) from which it started.

The magnetic field dying down has thus produced an induced current in the secondary winding, and in addition it will also set up a self-induced current in the primary winding. As the break in the primary circuit is made at the vibrator points, a large spark would occur there and very soon burn them away. To absorb the extra current which causes this spark a condenser is connected across the points by the wires (v) and (w). When the circuit is opened at (o) the self-induced current of the primary winding flows in the same direction as the original battery current. As the condenser has less resistance than the air gap which this current would have to jump at (o) it absorbs the current, and immediately that the condenser is charged, it discharges. The contact points (o) of the vibrator being separated at this time, the current from the condenser cannot pass through them to get to

its other side, but must travel back through the primary winding in the opposite direction to that in which the battery current was flowing, and thus demagnetizes the core.

As the more rapid the change is made from a strong magnetic field to a weak magnetic field, the higher the voltage will be; this will considerably raise the voltage of the secondary winding and give a much better spark at the spark plug. The condenser, therefore, performs two functions, that of absorbing the undesirable spark which without it would occur at the vibrator points, and of giving a much better spark in the spark plug.

Timer and Distributor Forms.—Anyone familiar with the basic principles of internal combustion engine action will recognize the need of incorporating some device in the ignition system, which will insure that the igniting spark will occur only in the cylinder that is ready to be fired and at the right time in the cycle of operations. There is a certain definite point at which the spark must take place, this having been determined to be at the end of the compression upstroke, at which time the gas has been properly compacted and the piston is about to start returning to the bottom of the cylinder again. Timers or distributors are a form of switch designed so that hundreds of positive contacts which are necessary to close and open the circuit may be made per minute without failure.

When the device is employed to open and close a low-tension circuit, it is known as a commutator or timer, and when used in connection with current of high voltage they are called secondary distributors. Certain constructional details make one form different from the other, and while they perform the same functions they vary in design. Such distributing devices are always driven by positive gearing from the engine and are timed so the sparks will occur in the cylinders at just the proper ignition time. The usual construction is to use a fixed case which carries one or more contact members suitably disposed around its periphery and a central revolving member or cam which contacts with the points on the body of the device to close any desired circuit. On a four-cycle engine the cam is revolved at one-half the engine speed and the timer is usually driven from the cam shaft. In two-cycle engines

the revolving member of the timer turns at engine speed, and should be driven directly from and at the same speed as the crank shaft.

Simple timer forms suitable for one-cylinder motors are shown at Fig. 30. The simplest one, depicted at A, consists of a rocking member of fiber or other insulating material which carries a steel spring that is normally out of engagement with the surface of the cam. When the point of the cam brushes by the contact spring,

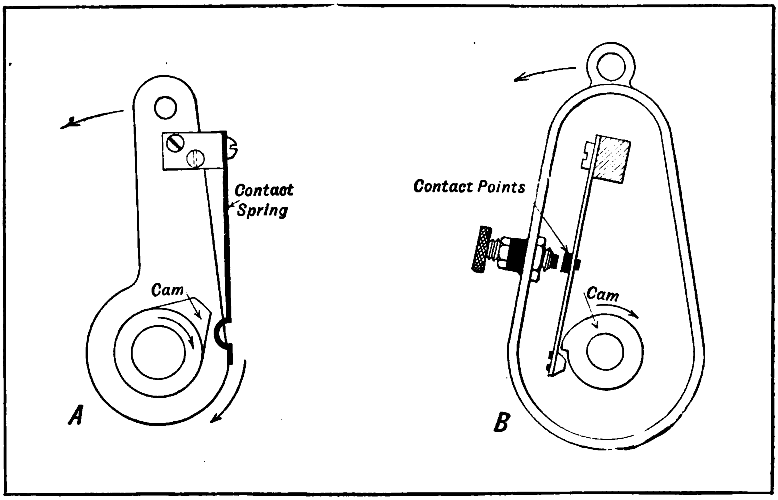


Fig. 30.—Simple Forms of Contact Breakers or Timers Used on One Cylinder Engines. A—Wipe Contact. B—Touch Contact.

any circuit in which the device is incorporated will be closed and current will flow from the battery or dynamo to the transformer coils and spark plugs which are depended on to furnish a spark of sufficient intensity to insure ignition of the gas. It is desirable that the member which carries the contact spring be capable of a certain degree of movement, in order that the spark time may be advanced or retarded to suit various running conditions. In the form shown if the top of the casing is pushed in the direction of the arrow, the contact spring will come in contact with the point of the cam which is turning in the direction indicated sooner than

it will if the base member is rocked in a reverse direction and the contact spring pulled away from the point of the cam instead of being moved forward to meet it. The wipe contact form is the simplest, but the spring is liable to wear at the point of contact and may break off and cause trouble. Such a device is more suitable for low-speed engines that it is for those which have high crank-shaft velocity.

The single-cylinder timer depicted at B is a form that is widely used on high-speed engines and contact is made between a pair of platinum contact points which just touch each other instead of wiping. Platinum is a material that is not affected by the arcing or heat of the spark as much as steel or brass would be and provides a more positive contact. In the wipe contact form the continual brushing action of the cam against the spring tends to keep the contact surfaces clean, but this condition does not obtain in the simple touch contact of the form shown at B. The casing is rocked in the direction of the arrow to advance a spark in either case. The form shown at B is more economical of current because the contact is shorter and is more suitable for high-speed engines. While the forms considered prove practical in their application to simple one- and two-cylinder engine forms, they are very heavy or clumsy appliances when used for four-cylinder engines, as it is very hard to assemble the spring elements so that the contact will take place at the proper point in all cylinders.

When a timer is to be used in connection with a four- or six-cylinder engine the compact form shown at Fig. 31, A, is usually adopted. This has many desirable features and permits of timing the spark with great accuracy. The contact segments are spaced on quarters for a four cylinder and are imbedded in a ring of fiber which is retained in a casing of aluminum. The central revolving element carries a lever which has a roll at one end and a tension spring designed to keep the roller in contact with the inner periphery of the fiber ring at the other. The segments are of steel and are accurately machined and hardened, and as the surface of the roller is also hardened, this form of timer is widely used because it provides a positive contact and works smoothly at all engine speeds.

A secondary distributor which is employed to distribute both high and low tension current is shown at Fig. 31, B. This consists of a primary timing arrangement in the lower portion, and a secondary current-distributing segment at the upper portion. The central revolving member carries as many rolls as there are cylinders to be fired, these being spaced at the proper points in the

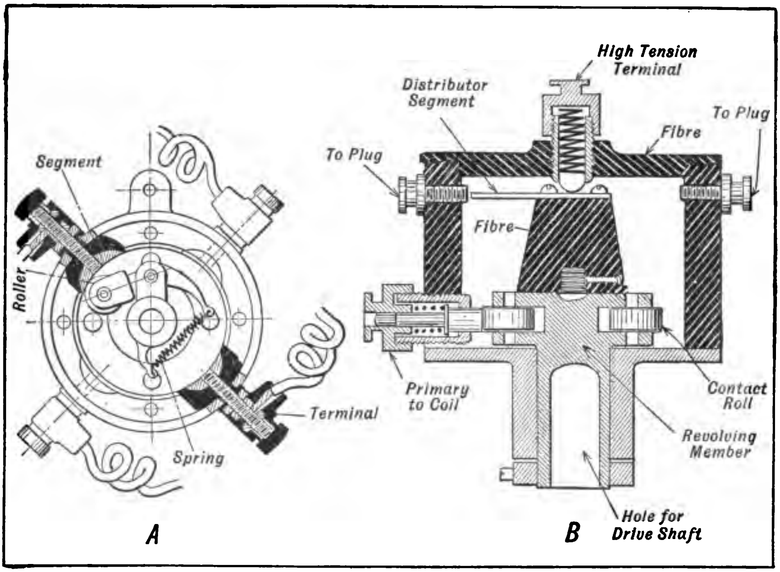


Fig. 31.—Timers Employed on Four Cylinder Engines. A—Four Contact Device for Commutating Primary Current. B—Combined Timer and Distributor, Directs Both High and Low Tension Energy.

circle to insure correct timing. One primary contact member is screwed into the casing, this contacting with the rolls as they revolve. At the upper portion of the case a number of terminals are inserted from which wires lead to plugs in the cylinders. When a timer of the form shown at A is used, a separate induction coil is needed for each cylinder and the number of units in the coil box and contact points on the timer will be the same as the number of cylinders to be fired. When a secondary distributor

is employed but one induction coil is needed for all cylinders, because the secondary or high-tension current from one unit is distributed to the spark plugs at the proper time. Various wiring diagrams will be presented to show the methods of using timers and distributors. It will be noticed that the high-tension portion of the distributor is well insulated from the primary circuit closing member at the lower end. This is necessary because current of high voltage is much more difficult to handle than that of lower pressure, and it is more liable to short circuit.

The arrangement of the contact points for various numbers of cylinders in roller contact timers is shown at Fig. 32. At A but one segment is provided, this obviously serving only one cylinder. The form depicted at B is utilized with a double-cylinder opposed motor or a twin-cylinder vertical type in which both connecting rods act on a common crank pin or crank pins in the same plane. As the explosions are evenly spaced and the intervals separating the sparks are equal, the contact segments are placed diametrically opposite and are separated by a space of 180 degrees. If the two-cylinder engine is a vertical form having opposed cranks, the explosions will not be separated by equal intervals, so the segments must be placed to compensate for the difference which exists in the time interval separating the power impulses. Two contact segments are imbedded in the insulating ring, the contacts being separated by a space of 90 degrees on one side and 270 degrees on the other. This form of timer is seldom used at the present time because the two-cylinder engine of the pattern for which it is adapted has been practically discarded.

When three cylinders are used the contact points are separated by a space of 120 degrees as shown at D. In a four-cylinder timer the contact segments are spaced on quarters of the circle and are separated by a space equal to 90 degrees. With a six-cylinder motor six segments are necessary, these being separated by a space of 60 degrees, as shown at F.

Another form of timer is shown at Fig. 33. In this the contact is established between balls and a contact roller. In order to eliminate the wear that is unavoidable with plain bearing timers the casing carries ball bearings which are used to support the

central hollow revolving member. Some timers of the form shown at Fig. 31, A, are fitted with a plain bearing which wears after the timer has been used and which produces irregular ignition due to a poor ground contact. Battery timers of the forms outlined are seldom used at the present time, as they have been succeeded by the more efficient short contact types. A notable excep-

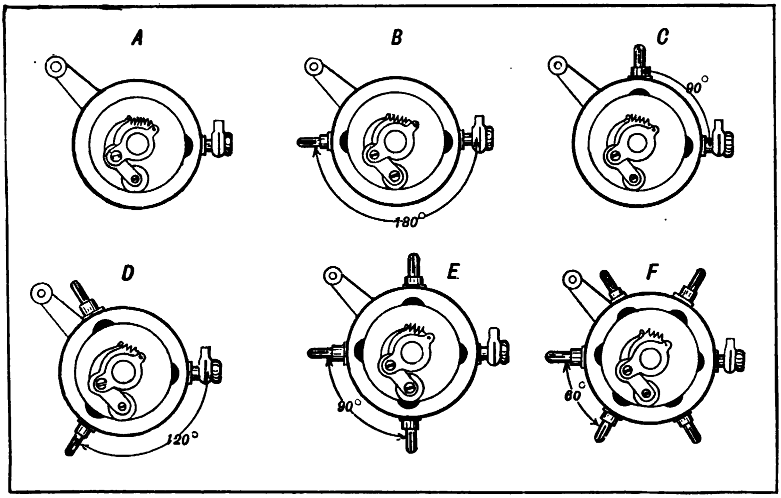


Fig. 32.—Showing Disposition of Contact Points on Timers for Differing Numbers of Cylinders. A—One Cylinder Type. B—Arrangement of Two Cylinder Opposed Motor. C—Contacts Separated by 90 Degrees in One Direction and 270 Degrees in the Other when Used on a Two Cylinder Vertical Engine with Opposed Crank Pins. D—Three Cylinder Form. E—Spacing for Four Cylinder Engines. F—Type Employed on Six Cylinder Power Plant.

tion to this almost general rule is the Ford car, which is manufactured in immense quantities and which utilizes the roller contact timer previously described.

One of the best known of the short contact forms of timer is the Atwater-Kent, which is usually combined with a secondary distributor as shown at Fig. 35. The method of placing this timing and distributing member in circuit is clearly shown in

wiring diagram Fig. 34. The advantage of a timer of the form shown, as contrasted to the simple type previously considered, is that a one unit induction coil will serve any number of cylinders from 2 to 8, whereas with the roller type shown at Fig. 31 a separate induction coil is needed for each cylinder to be fired.

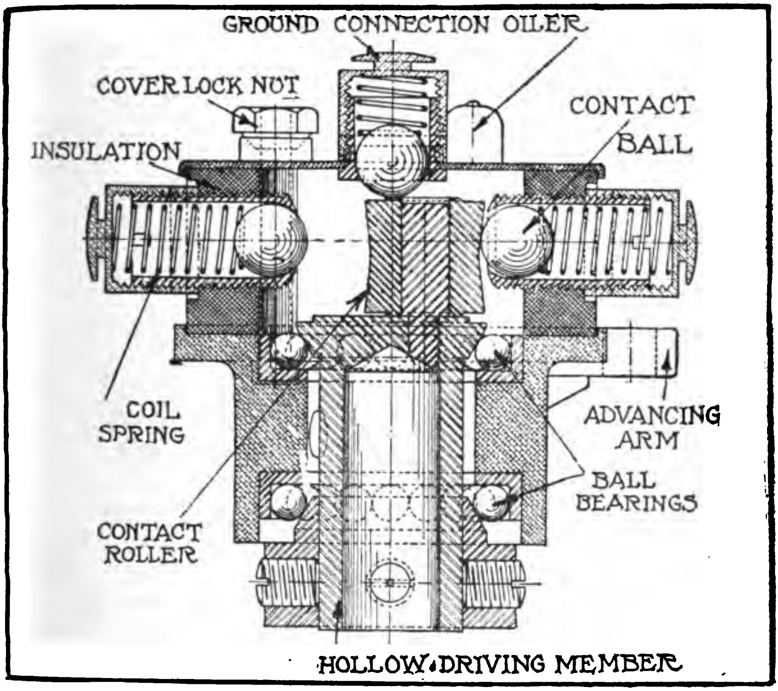


Fig. 33.—Sectional View Showing Construction of Ball Bearing, Ball Contact Timer.

It will be observed that the coil used with the Atwater-Kent system has five terminals, four of these being primary terminals, one at the center of the coil box a secondary or high tension terminal. A set of six dry cells connected in series is wired to one side of the coil box as indicated. One of the two remaining primary terminals runs to the primary contact at the bottom of the

interrupter, the other to a grounding screw attached to the interrupter casing. The secondary terminal is connected to the central terminal of the distributor, while the remaining four terminals are joined to the plugs in the engine cylinders in such order as to insure proper sequence of explosions. The external view of the Atwater-Kent uni-sparker is shown at Fig. 35, A. In this a centrifugal mechanism is contained in the lower part of the

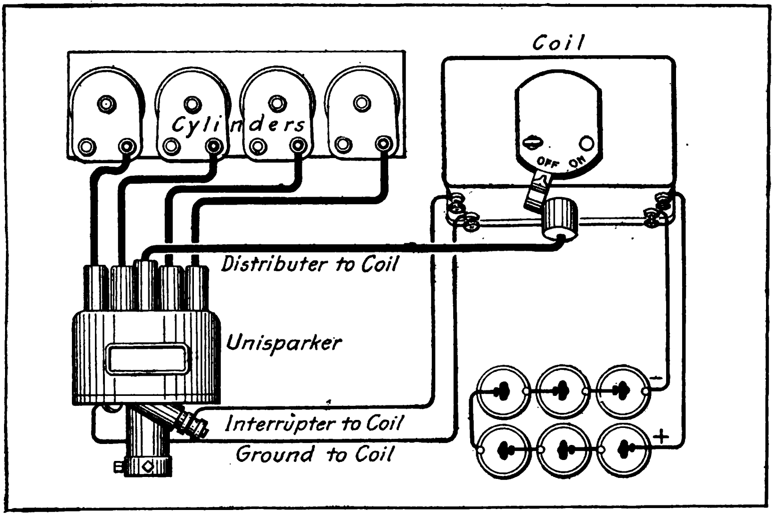


Fig. 34—Wiring Diagram of Atwater-Kent Uni-Sparker.

casing by which the spark is automatically advanced as the speed of the engine increases.

The only points that will wear on a device of this character are the contact points which are clearly shown in the view of the contact breaker mechanism at Fig. 36. The revolving shaft in the center has a number of notches, two, three, four, six, or eight, according to the number of cylinders to be fired, cut into it. A light, hardened steel trigger, B, is held against the shaft at this point by a small spring. On turning the shaft this trigger is carried forward by the notches in the shaft, and is suddenly released as the hook end leaves the notch. In so doing the back of the trigger

strikes a small pivoted hammer, D, situated between the trigger and the spring carrying the contact points. This causes the contact points, K, to open and close with remarkable rapidity, but one contact being made for each spark. When it is desired to adjust the platinum contact points, as when they show signs of wear, it is only necessary to remove one or more of a number of extremely thin washers under the head of the adjustment screw and to replace

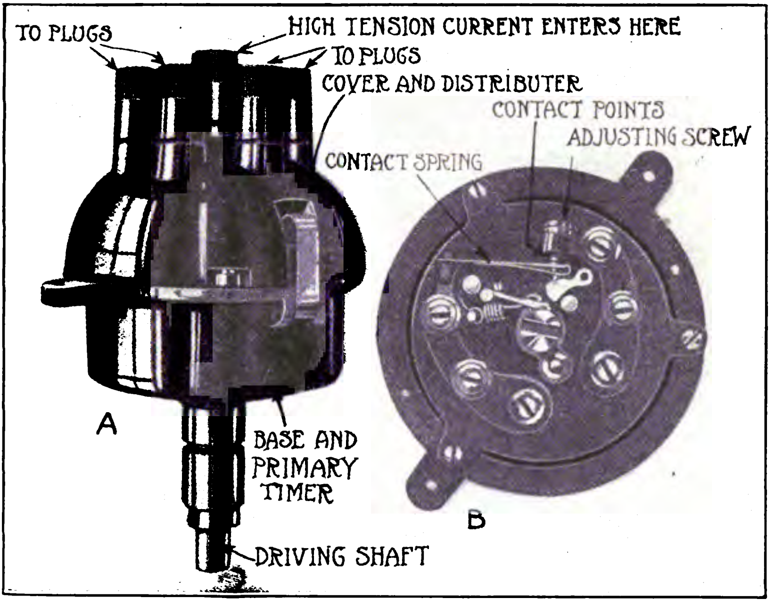


Fig. 35.—Showing Construction of Atwater-Kent Uni-Sparker.

the screw. The contact points should be absolutely clean and bright and have smooth contacting surfaces. The distributor portion of the device consists of a hard rubber block fitted to the top of the primary shaft, this carrying a brass quadrant that passes the high tension current to the spark plugs by means of the terminal points imbedded in the hemispherical cover. There is no actual contact between the rotating quadrant and the distributor points, as the high tension current is capable of jumping the very

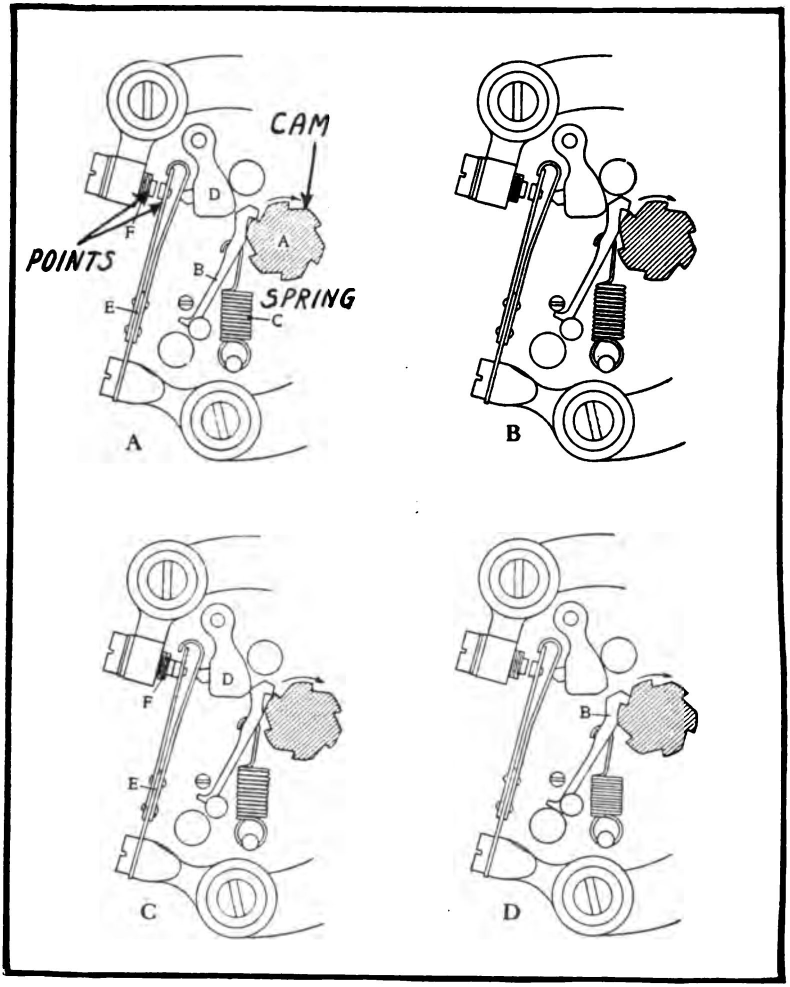


Fig. 36.—Diagrams Explaining Action of Atwater-Kent Contact Breaker.

slight gap that exists between them. Owing to there being no actual contact, there will be no depreciation in the distributor or upper portion. The center terminal, which is in connection with the induction coil, is a combination of carbon and brass, and a

light, flat spring on the quadrant bears against it to maintain positive electrical connection. The distributor cover is easily removed without the use of tools, as it is held by spring clips. Location or dowel pins in its lower edge insure that it will be replaced in the correct position.

One of the most popular of the combined starting, lighting and ignition systems is the Delco, which is shown at Fig. 37. For the present we will concern ourselves merely with discussing the ignition functions of the system, leaving the self-starting and electric lighting features for more comprehensive consideration later. Current is produced by a one unit type motor-generator, although the windings of the device when operated as a motor or a generator are entirely separate. The ignition current is obtained either from a storage battery which is kept in a state of charge by the generator, or from a set of dry cells which are carried for reserve ignition. The ignition system consists of a one unit non-vibrator coil, sometimes attached to the top of the motor generator, though it may be placed at any convenient part of the car and a dual automatic distributor and timer usually included as a part of the device as shown. When ignition current is supplied from the lighting circuit the current passes from the storage battery through a switch and out to the low tension winding of the coil, from whence it passes to the timer and from there to the frame, where it is grounded. The high tension current generated in the coil runs to the distributor, where it is switched to the spark plug in the different cylinders in turn.

When dry cells are used for ignition the operation is the same except that a device called "the ignition relay," and shown at the right of Fig. 38, is added to the circuit. The function of this device is to break the circuit immediately after it has been completed by the contact points of the timer, which is shown at the left. The use of the ignition relay results in a material saving of the battery current as the circuit is closed a much shorter time than is the case when the circuit is broken by the timer contacts themselves. The operation of the relay is not difficult to understand. The magnet A attracts the armature B when the circuit is completed through the timer. This action opens contact C and

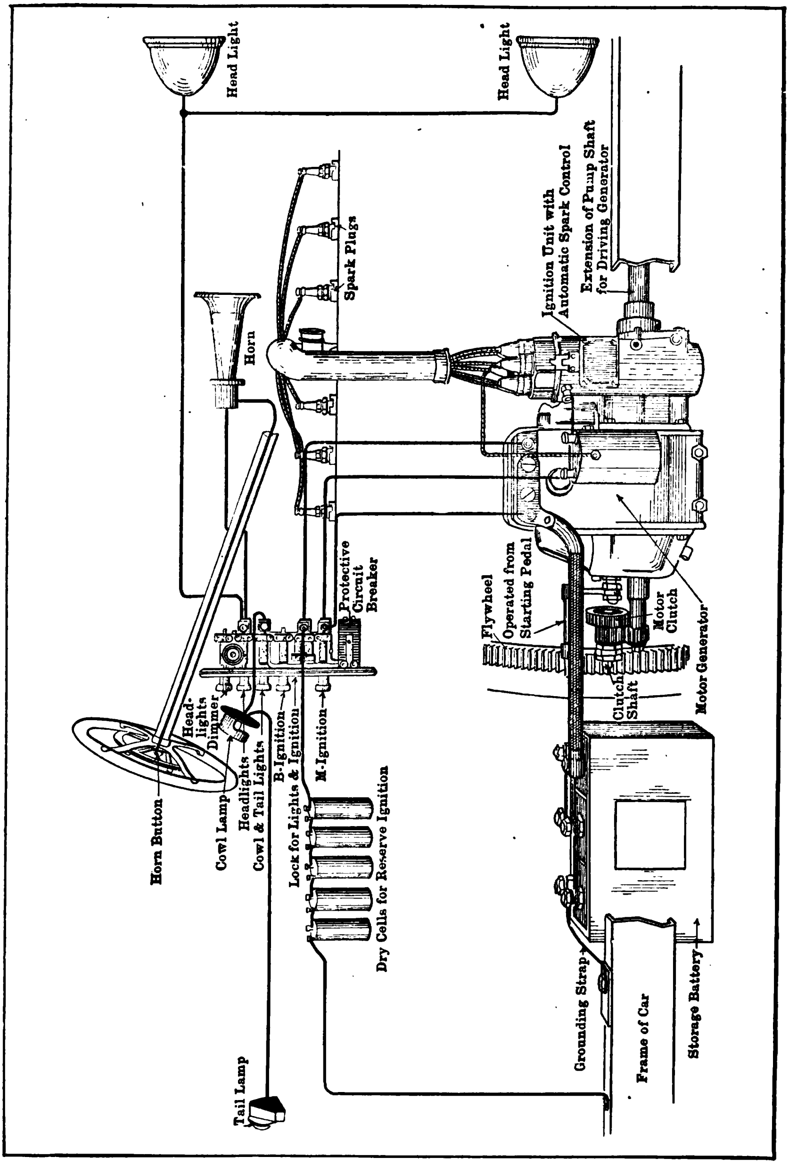


Fig. 37.—The Delco One Unit Starting, Lighting and Ignition System.

breaks the timer circuit. A condenser D is mounted besides the magnet coil A, in order to absorb the current produced by self-induction in the magnet winding, which would be apt to produce a hot spark between the contact points when they were separated if no means were taken for its disposal. The adjustment of the relay is at the pole piece E. This regulates the distance between the armature B and the magnet pole, and the gap between the contacts C. The adjustment is made by turning the notched head at E clockwise to increase, anti-clockwise to decrease, the gap between the contacts. The correct distance between contacts C when the armature B is pressed down is equal to approximately the thickness of one sheet of newspaper. A very simple way in which the adjustment can be made when the engine is running on the battery is to turn the notched head of the pole piece in the counter-clockwise direction until the motor ceases to fire. Then turn it four or five notches in the opposite direction. Under no conditions should the adjustment screw be turned very far in either direction. If the armature vibrates feebly when the starting button is pressed it indicates either weak dry cells or dirt between the relay or timer contacts.

The interior arrangement of one form of timer for both dry cells and storage battery current is shown at Fig. 38. The cam C is driven by a rotating shaft and establishes contact between the points when the cam rider rises on the point of the cam. When the cam rider drops into the notch between the high points the contact points separate. The same instructions that have been given for the contact points of the Atwater-Kent timer apply just as well in this case. While the contact points are but one-eighth inch in diameter, it is said that many thousands of miles of service may be obtained without readjusting. It is important that the contact spring, which is the straight one carrying the platinum point, should have a good tension outward against the cam rider member below it. It is said that this spring should be capable of supporting the weight of half a pound. If the tension is not sufficiently great the contact points barely break contact which permits the spark to arc between them, tending to burn them. The contact should be so adjusted that the contact spring is

forced away from the breaker member at least half the distance of the T-slot on the vertical part of the cam rider, when the latter is on the contact lobe of the cam. The contact points should open about ten one-thousandths (.010 inch) inch when the contact arm rests upon the back stop. The contact arm should clear the cam except at the contact lobe. A short wire connects the two posts

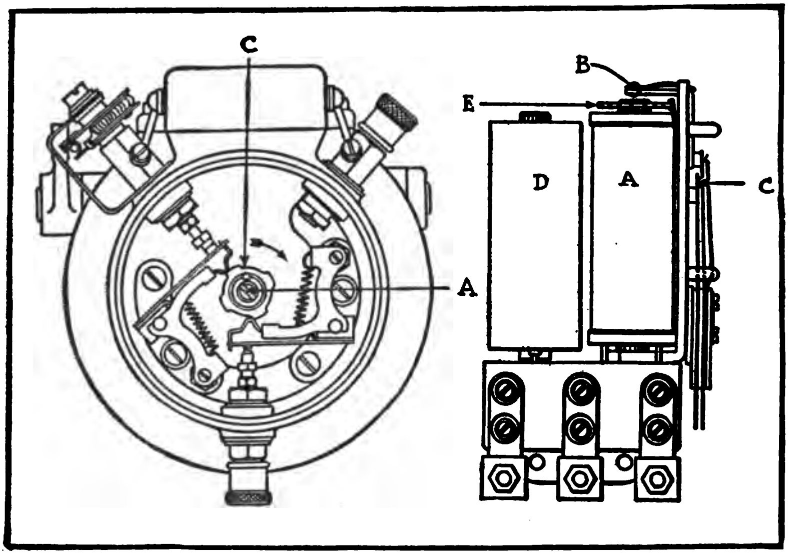


Fig. 38.—Delco Primary Timer at Left and Ignition Relay at Right.

of the breaker arms and this connection should always be inspected when making adjustments to insure that it has not been disturbed. It is said that if this wire is disconnected the current will pass through the contact spring, impairing its tension. Whenever the contact points are cleaned care should be taken to have the surfaces parallel.

In some of the Delco ignition systems an automatic spark advance mechanism is used. The usual method of wiring when the distributor is a separate member from the generator is shown at A, the left of Fig. 39. The construction of the automatic spark advance mechanism is shown at B. In this the shaft which trans-

mits motion to the timer is in the form of a tube T, revolved by spiral gears. An inclined slot is cut through the walls of this hollow driving member. A smaller shaft is carried inside of the hollow member, and a vertical slot is cut through this shaft in order to permit a pin to pass through it, said pin being actuated by a collar adapted to slide up and down on the outside of the hollow driving shaft. The pin passes through both the straight

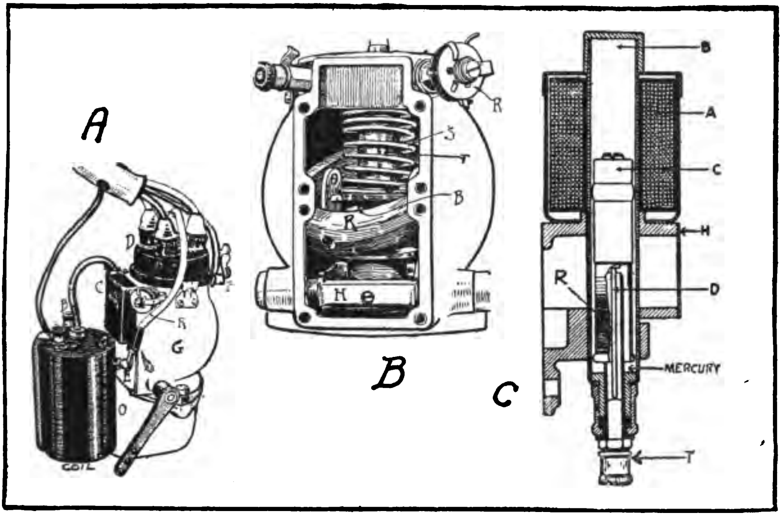


Fig. 39.—Parts of Delco 1914 System. A—Delco Timer, Coil and Condenser Assembly. B—Construction of Delco Automatic Spark Advance. C—Delco Voltage Regulator.

slot in the small shaft and the incline slot in the hollow driving member. If the collar holding the pin is moved it will change its angular relation with the small shaft which will advance the timing cam of the contact breaker. The collar is shifted by a spring loaded revolving ring R, which moves from the position shown in the drawing to a horizontal position as the speed increases. This ring is connected to the sliding collar and causes it to rise, advancing the spark as the engine speeds up or to fall, retarding the spark as the engine speed decreases. If desired, the spark

timing may be controlled independently of the automatic advance mechanism by a spark lever connected to the corresponding member on the steering wheel. The voltage regulator, which will be described when discussing the generating function of the Delco instrument, is shown at Fig. 39, C.

Condenser.—The condenser consists of two long strips of folded tinfoil insulated from each other by paraffined or oiled paper, and connected as shown in Fig. 40. The condenser has the property of being able to hold a certain quantity of electrical energy, and like the storage battery, will discharge this energy if there is any circuit between its terminal. As the distributor contacts open the magnetism commences to die out of the iron core, this induces a voltage in both the primary and secondary windings of the coil. This induced voltage in the primary winding amounts to from 100 to 125 volts. This charges the condenser which immediately discharges itself through the primary winding of the coil in the reverse direction from which the ignition current originally flows. This discharge of the condenser causes the iron core of the coil to be quickly demagnetized and remagnetized in the reverse direction, with the result that the change of magnetism within the secondary winding is very rapid, thus producing a high voltage in the secondary winding which is necessary for ignition purposes. In addition to rapidly demagnetizing the coil the condenser prevents sparking at the breaker contacts—thus it is evident that the action of the condenser can very seriously affect the amount of the spark from the secondary winding and the amount of sparking obtained at the timer contacts.

Ignition Coil.—This is sometimes mounted on top of the motor generator and is what is generally known as the ignition transformer coil. In addition to being a plain transformer coil it has incorporated in it a condenser (which is necessary for all high tension ignition systems) and has included on the rear end an ignition resistance unit. The coil proper consists of a round core of a number of small iron wires. Wound around this and insulated from it is the primary winding. The circuit and arrangement of the different parts are shown in Fig. 41. The primary current is supplied through the combination switch and resistance on the

coil, through the primary winding, to the distributor contacts. This is very plainly shown on the circuit diagram. It is the interrupting of this primary current by the timer contacts together with the action of the condenser which causes a rapid demagnetization of the iron core of the coil that induces the high tension current in the secondary winding. This secondary winding consists of sev-

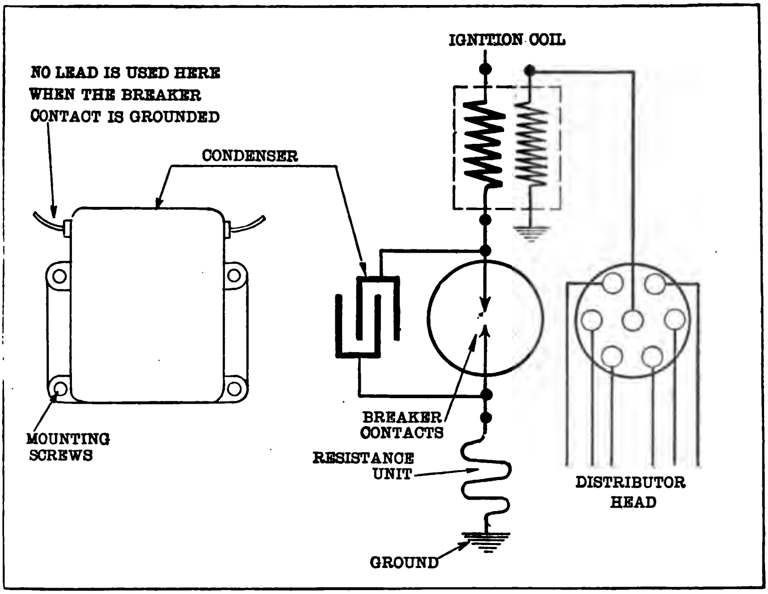


Fig. 40.—Simplified Wiring Diagram Showing Action of Delco Ignition System.

eral thousand turns of very fine copper wire, the different layers of which are well insulated from each other and from the primary winding, one end of which terminates at the high tension terminal about midway on top of the coil. It is from this terminal that the high tension current is conducted to the distributor where it is distributed to the proper cylinders by the rotor shown in Fig. 42.

Ignition Resistance Unit.—The ignition resistance unit which is shown in Fig. 41 is for the purpose of obtaining a more nearly

uniform current through the primary winding of the ignition coil at the time the distributor contacts open. It consists of a number of turns of iron wire, the resistance of which is considerably more than the resistance of the primary winding of the ignition coil. If the ignition resistance unit was not in the circuit and the coil was so constructed as to give the proper spark at high speeds, the primary current at low speeds would be several times its normal value with serious results to the timer contacts. This is evident from the fact that the primary current is limited by the resistance

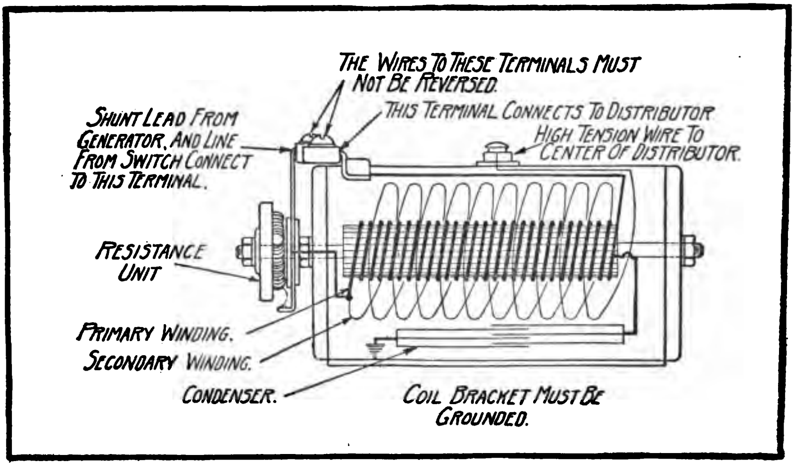


Fig. 41.—Sectional View Showing Arrangement of Wiring in Delco Ignition Coil.

of the coil and resistance unit by the impedence of the coil. (Impedence is the choking effect which opposes any alternating or pulsating current magnetizing the iron core.) The impedence increases as the speed of the pulsations increase. At low speeds the resistance of the unit increases, due to the slight increases of current heating the resistance wire.

The Circuit Breaker.—The circuit breaker is mounted on the combination switch as shown in Fig. 42. This is a protective device which takes the place of a fuse block and fuses. It prevents the discharging of the battery or damage to the switch or wiring

to the lamps, in the event of any of the wires leading to these becoming grounded. As long as the lamps are using the normal amount of current the circuit breaker is not affected. But in the event of any of the wires becoming grounded an abnormally heavy current is conducted through the circuit breaker, thus producing a strong magnetism which attracts the pole piece and opens the con-

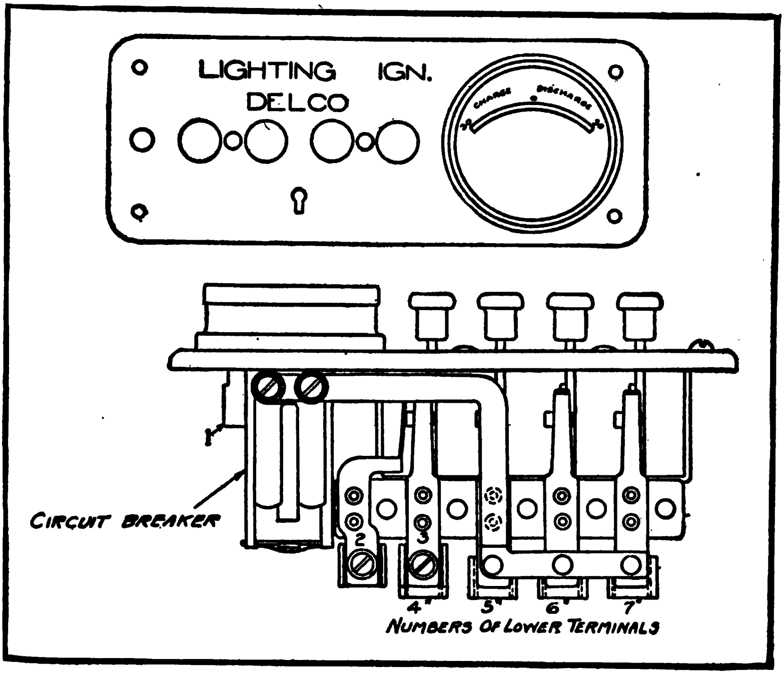


Fig. 42.—Delco Combination Switch with Ammeter and Circuit Breaker Included.

tacts. This cuts off the flow of current which allows the contacts to close again and the operation is repeated, causing the circuit breaker to pass an intermittent current and give forth a vibrating sound. It requires 25 amperes to start the circuit breaker vibrating, but once vibrating a current of three to five amperes will cause it to continue to operate. In case the circuit breaker vibrates repeatedly, do not attempt to increase the tension of the spring, as

the vibration is an indication of a ground in the system. Remove the ground and the vibration will stop.

The Ammeter.—The ammeter on the right side of the combination switch is to indicate the current that is going to or coming from the storage battery, with the exception of the cranking current. When the engine is not running and current is being used for lights, the ammeter shows the amount of current that is being used and the ammeter hand points to the discharge side, as the current is being discharged from the battery. When the engine is running above generating speeds and no current is being used for lights or horn, the ammeter will show charge. This is the amount of current that is being charged into the battery. If current is being used for lights, ignition and horn in excess of the amount that is being generated, the ammeter will show a discharge as the excess current must be discharged from the battery, but at all ordinary speeds the ammeter will read charge.

Construction of 1916 Delco Ignition Distributor.—It is well understood that a rich mixture burns quicker than a lean one. For this reason the engine will stand more advance with a half open throttle than with a wide open throttle, and in order to secure the proper timing of the ignition due to these variations and to retard the spark for starting, idling and carburetor adjusting, the Delco distributor also has a manual control. The automatic feature of this distributor is shown in Fig. 43. With the spark lever set at the running position on the steering wheel (which is nearly all the way down on the quadrant), the automatic feature gives the proper spark for all speeds excepting a wide open throttle at low speeds, at which time the spark lever should be slightly retarded. When the ignition is too far advanced it causes loss of power and a knocking sound within the engine. With too late a spark there is a loss of power (which is usually not noticed excepting by an experienced driver or one very familiar with the car), and heating of the engine and excessive consumption of fuel is the result. The timer contacts shown at D and C (Fig. 43) are two of the most important points of an automobile. Very little attention will keep these in perfect condition. These are of tungsten metal, which is extremely hard and

requires a very high temperature to melt. Under normal conditions they wear or burn very slightly and will very seldom require attention; but in the event of abnormal voltage, such as would be obtained by running with the battery removed, or with the ignition resistance unit shorted out, or with a defective condenser, these contacts burn rapidly and in a short time will cause serious ignition trouble. The car should not be operated with the battery removed.

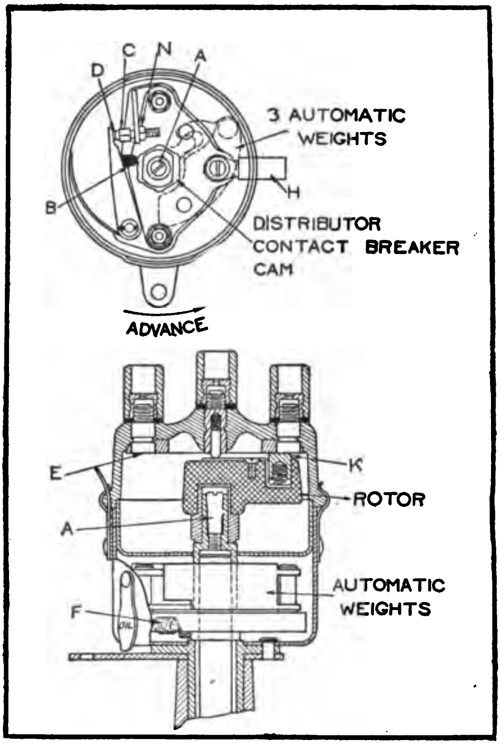


Fig. 43.—Showing Construction of 1916 Delco Distributor for Six Cylinder Ignition. Note Six Lobe Cam.

It is a very easy matter to check the resistance unit by observing its heating when the ignition button is out and the contacts in the distributor are closed. If it is shorted out it will not heat up, and will cause missing at low speeds. A defective condenser such as will cause contact trouble will cause serious missing of the ignition. Therefore, any one of these troubles are comparatively easy to locate and should be immediately remedied. These contacts should be so adjusted that when the fiber block B is on top of one of the lobes of the cam the contacts are opened the thickness of the gauge on the distributor wrench. Adjust contacts by turning contact screw C and lock with nut N. The contacts should be dressed with fine emery cloth so that they

meet squarely across the entire face. The rotor distributes the high tension current from the center of the distributor to the proper cylinder. Care must be taken to see that the distributor head is properly located, otherwise the rotor brush will not be in contact with the terminal at the time the spark occurs.

Combination Switch.—The combination switch is located on the cowl board and makes the necessary connections for ignition and

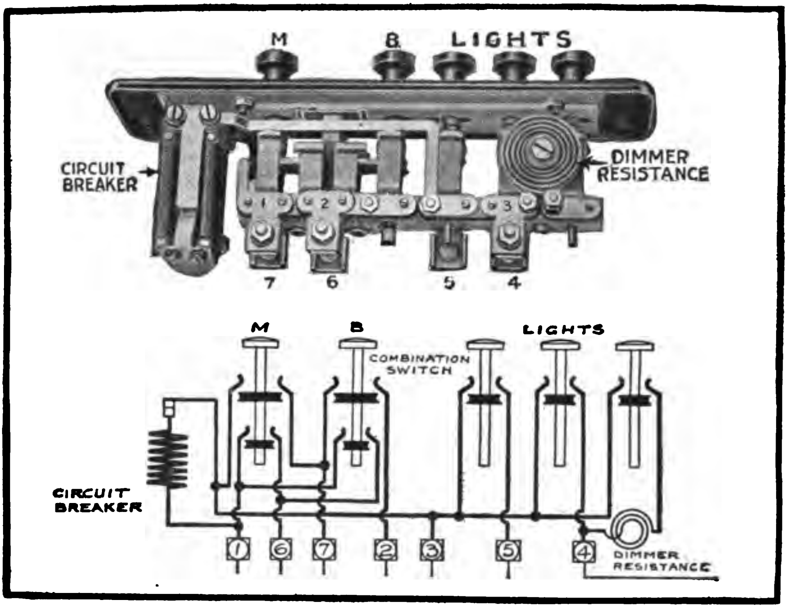


Fig. 44.—Delco Combination Switch without Amperemeter Showing Headlight Dimmer Resistance.

lights. The "M" button controls the magneto type ignition and the "B" button, the dry battery ignition. In addition to this both the "M" and "B" buttons control the circuit between the generator and storage battery. When the circuit between the generator and the storage battery is closed by either the "M" or "B" button on the combination switch, the direction of flow of the current is from the battery to the generator when the engine is not running,

as well as when it is running below 300 R. P. M. But the amount of current that flows from the battery at the lowest possible engine speeds is so small that it is negligible. That used on Buick 1915 cars is shown at Fig. 44, the type supplied on 1916 cars is outlined at Fig. 42.

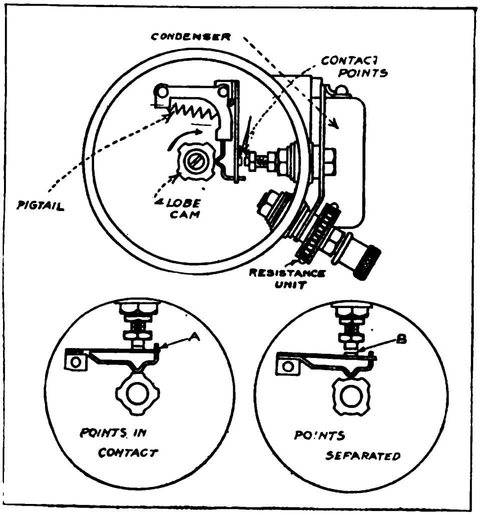


Fig. 45.—Simplified Diagrams Showing Action of Delco Timer.

To Time the Ignition.—1. Fully retard the spark lever. 2. Turn the engine to mark on flywheel about one inch past dead center to the "7 degree" line, with No. 1 cylinder on the firing stroke. 3. Loosen screw in center of timing mechanism (Fig. 45) and locate the proper lobe of the cam by turning until the

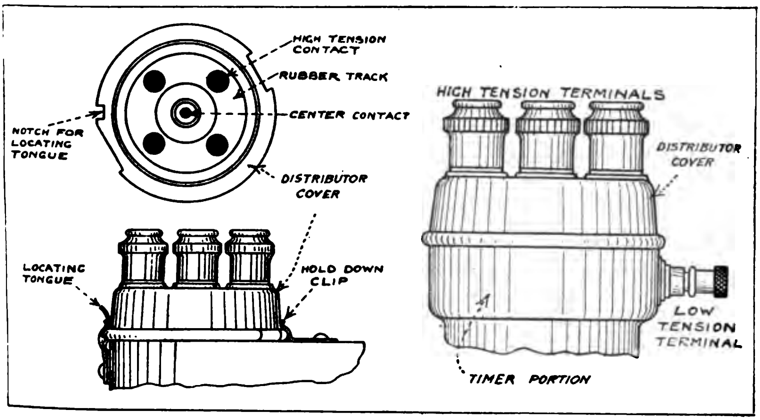


Fig. 46.—How Cover is Removed from Delco Distributor.

button on the rotor comes under the high tension terminal for No. 1 cylinder. 4. Set this lobe of the cam so that when the back lash in the distributor gears is rocked forward the timing contacts will be open, and when the back lash is rocked backward the contacts WILL JUST CLOSE. Tighten screw and replace rotor and distributor head. The construction of the distributor head is clearly shown at Fig. 42, which shows the internal view, while Fig. 46 shows the exterior and plan of contact brushes.

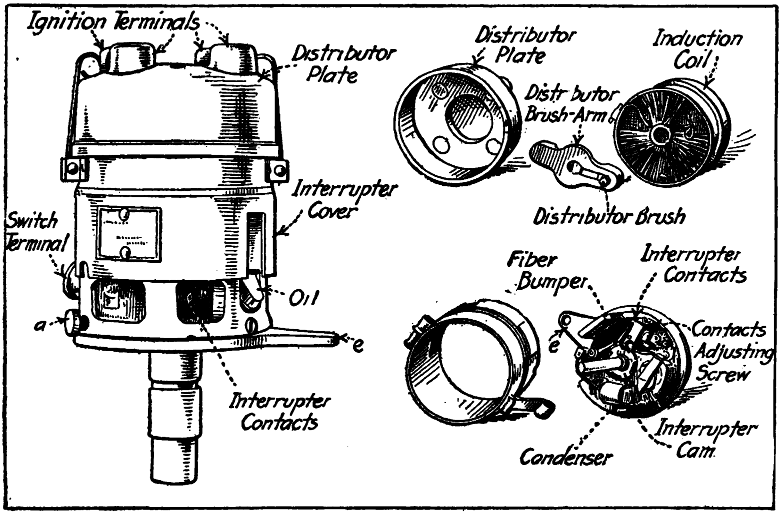


Fig. 47.—Parts of Westinghouse Timer-Distributor, which Includes the Induction Coil.

Westinghouse Vertical Ignition Unit.—The Westinghouse vertical ignition unit, shown at Fig. 47, can be used for ignition from storage batteries or plain lighting generators. This set contains interrupter, spark coil and condenser, and distributor, all in one unit. One wire from the battery or generator to the ignition unit and one wire to each spark plug are all that are required—the simplest possible connections. The interrupter, located at the lower end of the set, has the same type of circuit-breaker as that

on the Westinghouse ignition and lighting generators, but no automatic spark advance feature. It can be used equally efficiently for either direction of rotation without change. The interrupter is enclosed by a spring collar which can be readily removed for inspection or adjustment of the contacts. The collar makes a tight joint and is clamped by a screw which prevents it from slipping. The spark coil is embedded in heat-proof insulating material, and the condenser is well insulated. Both are contained in a tube of Bakelized Micarta which forms the body of the unit. The distributor is of very simple construction with a wiping brush contact of the same type as that used on the ignition generators. It clamps to the upper end of the set. The wiring diagram of this system is shown at Fig. 48. The device is sometimes mounted in connection with a generator when that member is driven by direct gear connection from cam shaft which provides a properly timed drive for the ignition unit. This method of application is clearly shown at Fig. 49.

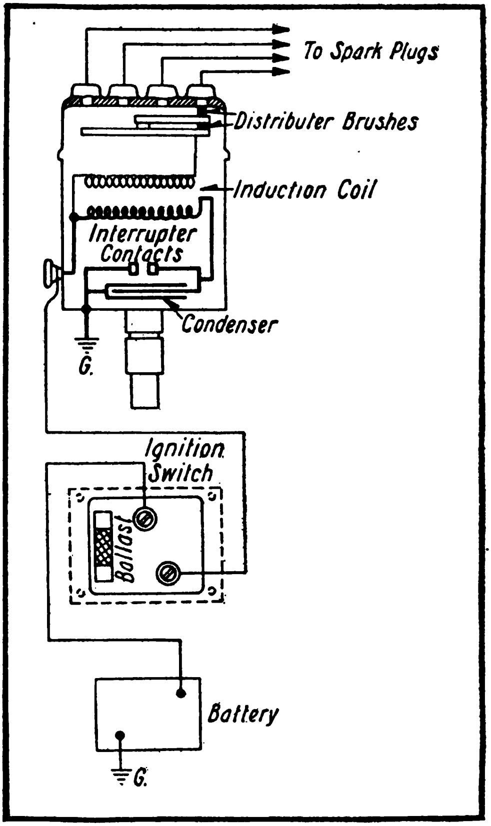


Fig. 48.—Showing Internal Wiring of Westinghouse Timer-Distributor and Coil Ignition Unit.

Spark Plug Design and Application.—With the high-tension system of ignition the spark is produced by a current of high voltage jumping between two points which break the complete circuit, which would exist otherwise in the secondary coil and its external connections. The spark plug is a simple device which consists of two terminal electrodes carried in a suitable shell member, which is screwed into the cylinder. Typical spark plugs are shown in section at Figs. 50 and 51, and the construction can be easily understood. The secondary wire from the coil is attached to a terminal at the top of a central electrode member, which is supported in a bushing of some form of insulating material. The type shown at A employs a molded porcelain as an insulator, while that depicted at D uses a bushing of mica. The insulating bushing and electrode are housed in a steel body, which is provided with a screw thread at the bottom, by which it is screwed into the combustion chamber.

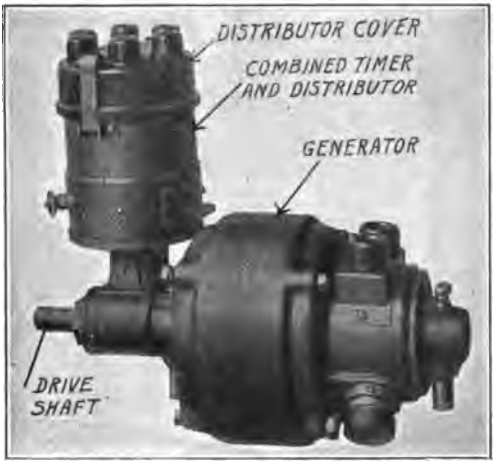


Fig. 49.—Westinghouse Generator with Attached Timer-Distributor Coil Unit.

When porcelain is used as an insulating material it is kept from direct contact with the metal portion by some form of yielding packing, usually asbestos. This is necessary because the steel and porcelain have different coefficients of expansion and some flexibility must be provided at the joints to permit the materials to expand differently when heated. The steel body of the plug which is screwed into the cylinder is in metallic contact with it and carries sparking points which form one of the terminals of the air gap over which the spark occurs. The current entering

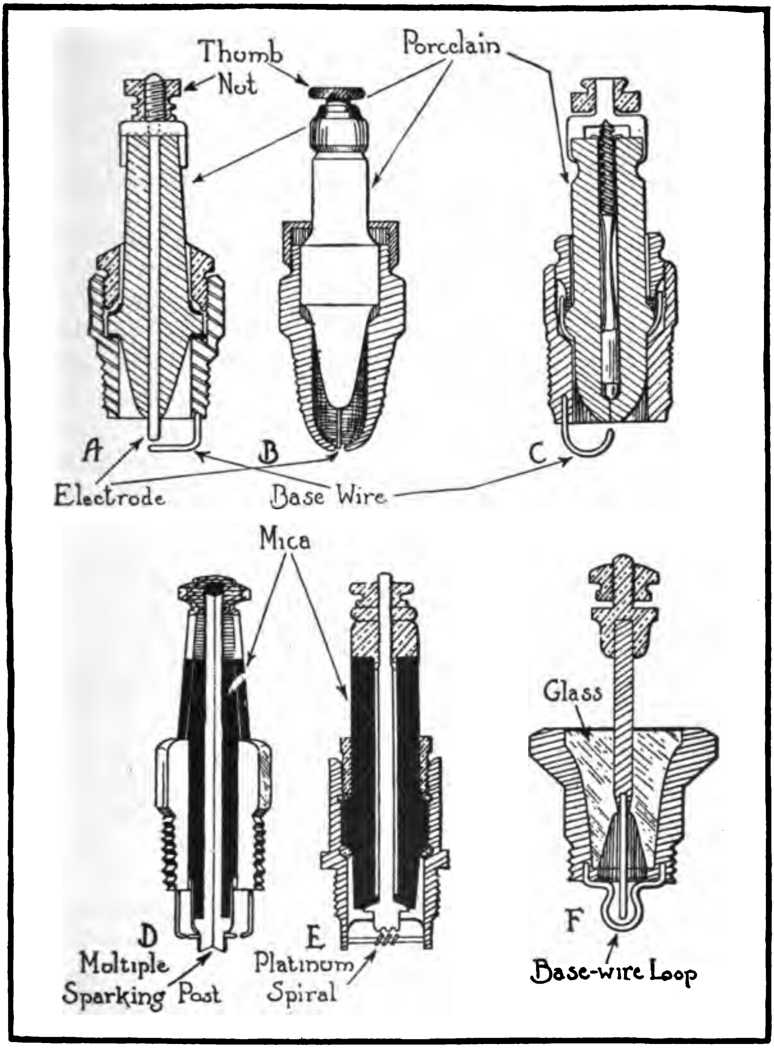


Fig. 50.—Sectional Views Showing Construction of Typical Spark Plugs.

at the top of the plug cannot reach the ground, which is represented by the metal portion of the engine, until it has traversed the full length of the central electrode and overcome the resistance of the gap between it and the terminal point on the shell. The porcelain bushing is firmly seated against the asbestos packing by means of a brass screw gland which sets against a flange formed on the porcelain, and which screws into a thread at the upper portion of the plug body.

The mica plug shown at D is somewhat simpler in construction than that shown at A. The mica core which keeps the central electrode separated from the steel body is composed of several layers of pure sheet mica wound around the steel rod longitudinally, and hundreds of stamped mica washers which are forced over this member and compacted under high pressure with some form of a binding material between them. Porcelain insulators are usually molded from high grade clay and are approximately of the shapes desired by the designers of the plug. The central electrode may be held in place by mechanical means such as nuts, packings, and a shoulder on the rod, as shown at A. Another method sometimes used is to cement the electrode in place by means of some form of fire-clay cement. Whatever method of fastening is used, it is imperative that the joints be absolutely tight so that no gas can escape at the time of explosion. With a mica plug the electrode and the insulating bushing are really a unit construction and are assembled in permanent assembly at the time the plug is made.

Other insulating materials sometimes used are glass, steatite (which is a form of soapstone), and lava. Mica and porcelain are the two common materials used because they give the best results. Glass is liable to crack while lava or the soapstone insulating bushings absorb oil. The spark gap of the average plug is equal to about $\frac{1}{16}$ of an inch for coil ignition and from $\frac{1}{64}$ to $\frac{1}{32}$ of an inch when used in magneto circuits. A simple gauge for determining the gap setting is the thickness of an ordinary visiting card for magneto plugs, or a space equal to the thickness of a worn dime for a coil plug. The insulating bushings are made in a number of different ways, and while details of construction vary,

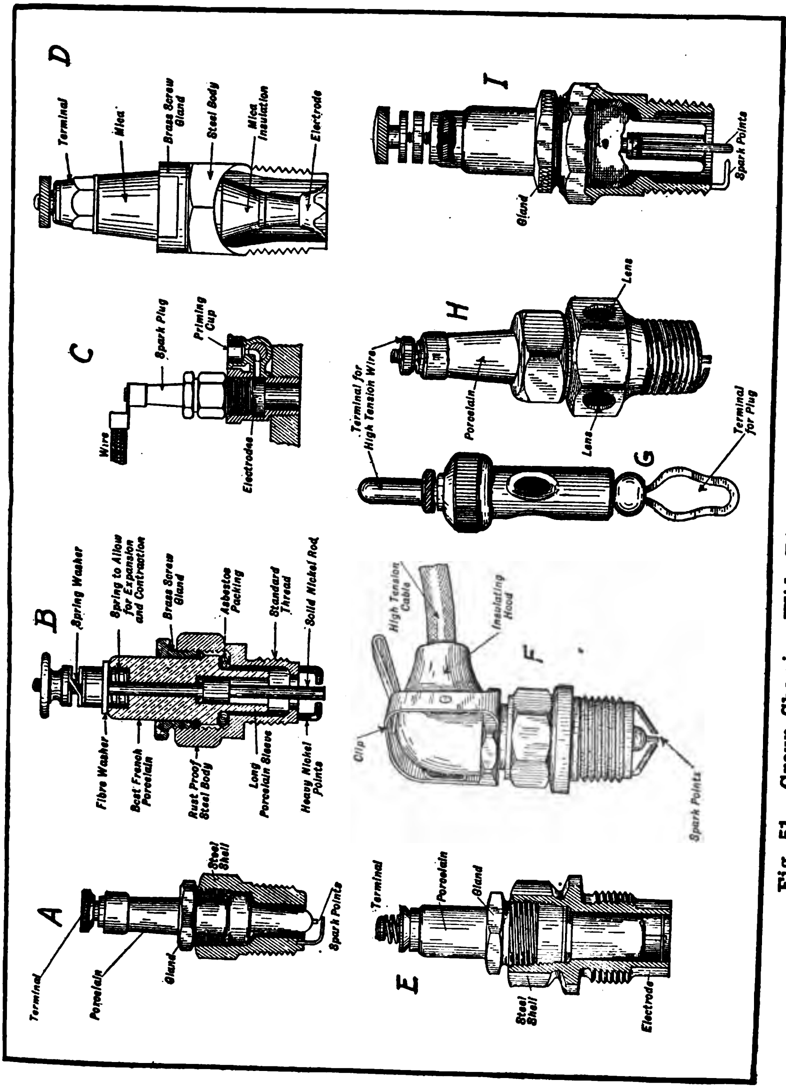


Fig. 51.—Group Showing Wide Diversity in Spark Plug Design.

spark plugs do not differ essentially in design. Four different forms of plugs using porcelain insulation are shown in part section at Fig. 51. Porcelain is the material most widely used because it can be glazed so that it will not absorb oil, and it is subjected to such high temperature in baking that it is not liable to crack when heated.

The spark plugs may be screwed into any convenient part of the combustion chamber, the general practice being to install them in the caps over the inlet valves, or in the side of the combustion chamber, so the points will be directly in the path of the entering fresh gases from the carburetor. The methods of spark plug installation commonly used are shown at Fig. 52. At A the plug is screwed into a threaded hole which passes through the valve cap in such a manner that the points are in a pocket. This is not considered to be as good as the method depicted at B, where the interior of the valve cap is recessed out so there is considerable clear space around the spark points. When the electrodes are carried in a pocket they are more liable to become short circuited by oil or carbon accumulations, because it is difficult for the fresh gases to reach them and the pocket tends to retain heat. Ignition is not so certain because some of the burned gases may be retained in the pocket and prevent the fresh gas from getting in around the spark gap. With a recess, as shown at B, conditions are more favorable because the fresh gases can sweep the points of the spark plug and keep them clear, and also because of the larger space any burned products retained in the cylinder are not so apt to collect around the plug point. The method of installation shown at C causes the plug to heat and is not as efficient as that outlined at D, which permits ready transference of heat to the cooling water in the jacket spaces.

On some types of engines which are not provided with compression relief, or priming cocks, plugs are sometimes installed, as shown at Fig. 51, C. A special fitting, which carries a priming cup at one side, is screwed into the cylinder and the spark plug is fitted to its upper portion. When it is desired to relieve the compression, the valve portion is turned in such a way that a passage is provided from the interior of the fitting to the outer air.

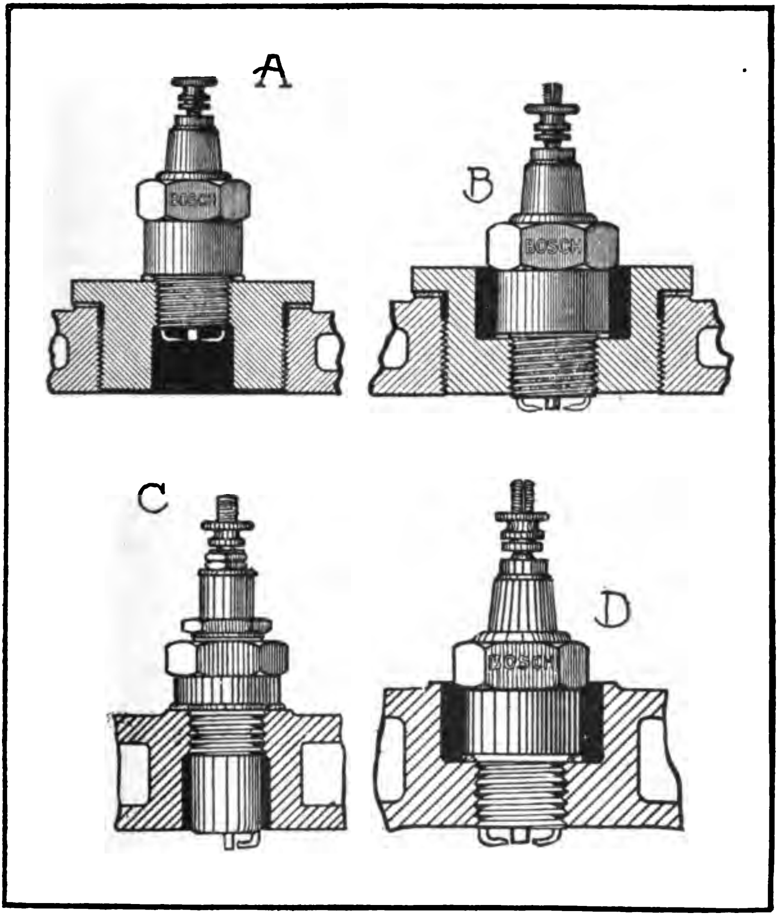


Fig. 52.—Illustrations Showing Proper and Improper Placing of Spark Plugs.

At the same time when the valve is in the position shown in illustration, gasoline may be introduced into the cylinder for priming purposes. It is advanced that this method of construction also provides a simple means of freeing the plug points from oil or particles of carbon if the cock is opened while the engine is running. The high pressure gas which brushes by the points on

its way out of the cylinder tends to dislodge any particle of foreign matter which may be present near the spark gap. The same objections apply to this method of mounting as to that illustrated at A.

Some spark plugs have been designed with a view of permitting one to see if the charge is being exploded regularly in the cylinder by some form of transparent material for insulation, so that the light produced by the explosion could be seen from the outside of the cylinder. The simplest method of determining if a spark is occurring regularly between the points is to use some form of spark gap which is interposed between the source of current and the plug terminal. A device of this nature is shown at Fig. 51, G. It consists of a body of insulating material which carries in a glass tube two points, which are separated by a slight air space. The eye or hook end is attached to the plug terminal, while the other end is attached to the secondary wire. If the current is passing between the points of the plug, a spark will take place between the points of the auxiliary spark gap every time one occurs between the points of the plug in the cylinder.

It is claimed that there are certain advantages obtained when a spark gap is used in the circuit, in that the spark in the cylinder is more effective and less liable to be short circuited by particles of foreign matter. At the other hand, others contend that the current must be stronger to jump two gaps than would be required if only the resistance of one was to be overcome. While very popular at one time, the spark gap is of rather doubtful utility and is seldom used at the present time, except as a means of indicating if spark has taken place between the points of the spark plug. It is apt to be somewhat misleading, however, because even if the points of the plug are short circuited and no spark is taking place between the plug points, and yet current is passing to the ground, a spark will continue to take place at the auxiliary spark gap. The device is useful in showing when there is a break or derangement of the wiring or coils.

A form of spark plug having glass bull's-eyes set into the plug shell or body is shown at Fig. 51, H. These simple lenses are made of specially compounded glass, which has a high resistance to heat

and every time an explosion takes place in the cylinder the light resulting causes a flash which is readily seen through the lens, If the flashing is regular it is safe to assume that the cylinder is functioning properly, but should the flashes be intermittent or separated by unequal intervals of time the cylinder is missing explosions.

It is often desirable to have a water-tight joint between the high-tension cable and the terminal screw on top of the insulating bushing of the spark plug, especially in marine applications. The plug shown at Fig. 51, F, is provided with an insulating member or hood of porcelain, which is secured by a clip in such a manner that it makes a water-tight connection. Should the porcelain of a conventional form of plug become covered with water or dirty oil, the high-tension current is apt to run down this conducting material on the porcelain and reach the ground without having to complete its circuit by jumping the air gap and producing a spark. It will be evident that wherever a plug is exposed to the elements, which is often the case in motor-cycle or motor-boat service, that it should be protected by an insulating hood which will keep the insulator dry and prevent short circuiting of the spark.

Spark plugs are made in infinite variety, more simple forms being shown at Fig. 50. Those in section at A, B and C utilize a porcelain insulator through which a central rod or electrode passes. This terminates at the top in a threaded member, to which the thumb nut is screwed. In most plugs using porcelain insulators a cap is cemented to the top of the porcelain in order to form a seating for the thumb nuts. The form outlined at A is the type of plug most generally used, as it is a simple and effective design. It is easier to clean the points or the interior of the body than in the form shown at B, which has a closed end and which must be dismembered in order to remove the sooty deposit from the insulator surface. The type of plug at C has a very fine wire imbedded in the lower portion of the porcelain, which is in connection with a conductor of heavier material used to transmit the current from the terminal nuts to the fine wire. The theory of action of a plug of this nature is that the fine wire

is not so apt to be short circuited by soot as the projecting electrode forms are, and that the spark tends to clear away material that might short circuit the current by burning it.

The plugs shown at D and E have mica insulators instead of porcelain. When mica is used a sheet of that material is wrapped around the central electrode several times, after which a series

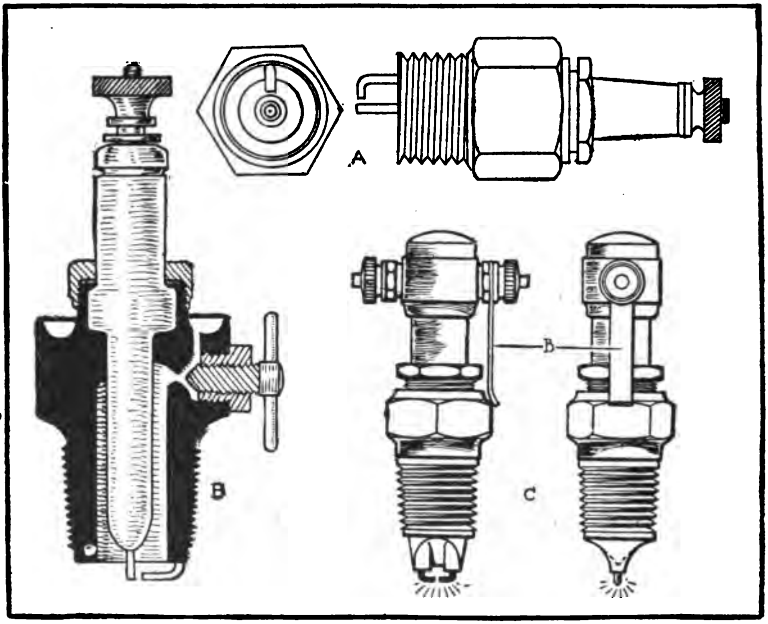


Fig. 53.—Conventional Type of Spark Plug at A, Showing Air Gap Between the Points. B—Priming Plugs. C—Two-Point Spark Plug.

of mica washers is clamped tightly together and turned down to form a smooth insulator. The plug at F is the only one marketed using glass insulation. Other plug forms made on the same general principles as that at A use lava or steatite as an insulator instead of the porcelain or mica. For all-around service the porcelain insulator gives the best results, as the mica and lava insulators are apt to become oil soaked and permit the current to short circuit through the insulator and the plug body instead

of jumping the air gap. Another representative form of spark plug showing the proper space between the spark points is shown at Fig. 53, A.

The plug at Fig. 53, B, is one that combines a priming feature and is intended for use in engines of the Ford type in which no provision is made for using priming cups or compression relief cocks. The plug body is formed in such a way that a needle valve fitting may be screwed into it, this being intended to close a passageway communicating from a channel around the top of the plug body to the interior of the plug body. It is said that if this needle valve is opened for a minute or so while the engine is running that there will be a tendency to clear the plug points of any loose oil or carbon. The compression may be relieved by opening the needle valve, and if it is desired to inject gasoline into the cylinder to promote easy starting this may be easily done by filling the channel or groove on top of the plug body with the fuel, then opening the needle valve to allow it to pass to the plug interior. The gasoline will run down the walls and collect around the spark points, where it will be readily ignited by the spark.

Plugs for Two-Spark Ignition.—On some forms of engines, especially those having large cylinders, it is sometimes difficult to secure complete combustion by using a single-spark plug. If the combustion is not rapid the efficiency of the engine will be reduced proportionately. The compressed charge in the cylinder does not ignite all at once or instantaneously, as many assume, but it is the strata of gas nearest the plug which is ignited first. This in turn sets fire to consecutive layers of the charge until the entire mass is aflame. One may compare the combustion of gas in the gas-engine cylinder to the phenomena which obtains when a heavy object is thrown into a pool of still water. First a small circle is seen at the point where the object has passed into the water, this circle in turn inducing other and larger circles until the whole surface of the pool has been agitated from the one central point. The method of igniting the gas is very similar as the spark ignites the circle of gas immediately adjacent to the sparking point, and this circle in turn ignites a little larger one concentric with it. The second circle of flame sets fire to more

of the gas, and finally the entire contents of the combustion chamber are burning.

While ordinarily combustion is sufficiently rapid with a single plug so that the proper explosion is obtained at moderate engine speeds, if the engine is working fast and the cylinders are of

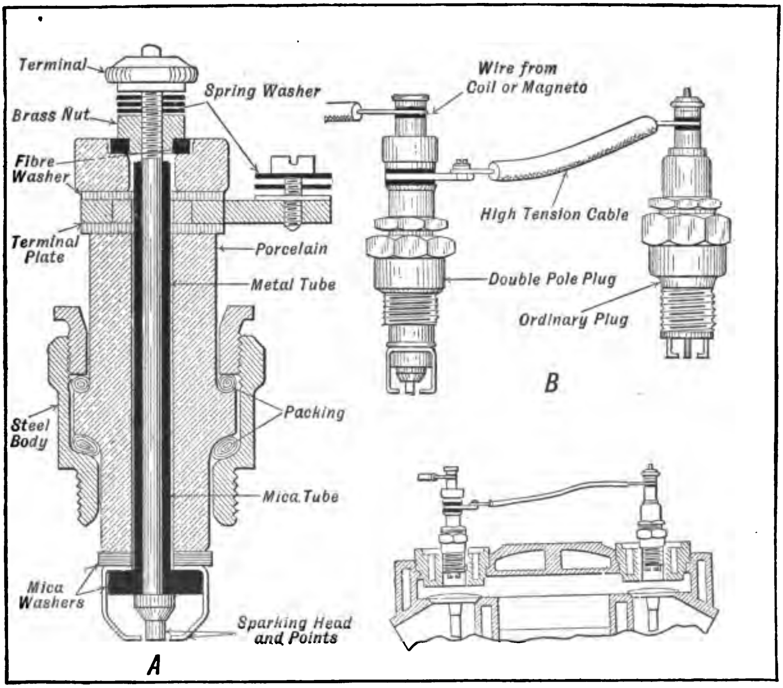


Fig. 54.—Double Pole Spark Plug and Method of Applying It to Obtain Two Sparks in Cylinder.

large capacity, more power may be obtained by setting fire to the mixture at two different points instead of but one. This may be accomplished by using two sparking plugs in the cylinder instead of one, and experiments have shown that it is possible to gain from twenty-five to thirty per cent. in motor power at high speed with two-spark plugs, because the combustion of the gas is accelerated by igniting the gas simultaneously in two places. To

fit a double-spark system successfully, one of the plugs must be a double pole member to which the high-tension current is first delivered, while the other may be one of ordinary construction.

A typical double-pole plug is shown in section at Fig. 54, A. In this member two concentric electrodes are used, these being well insulated from each other. One of these is composed of the usual form passing through the center of the insulating bushing, while the other is a metal tube surrounding the tube of insulating material which is wound around the center wire. The current enters the plug through the terminal at the top in the usual manner, but it does not go to the ground because the sparking points are insulated from the steel body of the plug which screws into the cylinder. After the current has jumped the gap between the sparking head and the point, it flows back to the terminal plate at the top, from which it is conducted to the insulated terminal of the usual type plug.

The method of wiring these plugs is shown at Fig. 54, B. The secondary wire from the coil or magneto is attached to the central terminal of the double-pole plug, and another cable is attached to the insulated terminal plate below it and to the terminal of the regular type plug. One is installed over the inlet valve, the other over the exhaust valve, if the system is fitted to a T head cylinder. Before the current can return to the source it must jump the gap between the points of the double-pole plug as well as those of the ordinary plug, which is grounded because it is screwed into the cylinder. When a magneto of the high-tension type furnishes the current a double distributor is sometimes fitted, which will permit one to use two ordinary single-pole plugs instead of the unconventional double-pole member. Each of the plugs is joined to an individual distributor, and as but one primary contact breaker or timer is used to determine the time of sparking at both plugs, the ignition is properly synchronized and the sparks occur simultaneously.

Sometimes a spark plug of the special form shown at Fig. 53, C, is used in connection with a regular spark plug of the form shown at A, the special plug being placed first in the circuit and joined to the regular plug by a length of wire bridging the free terminal

of the plug at C with that on top of the insulator of the regular pattern. As the plugs are in series, the current must jump the gap of both plugs and thus two sparks occur, which is said to increase power by accelerating the rate of flame propagation, which of course results in more energetic ignition. The insulator is shaped to form a double V, the sides being slightly concave and

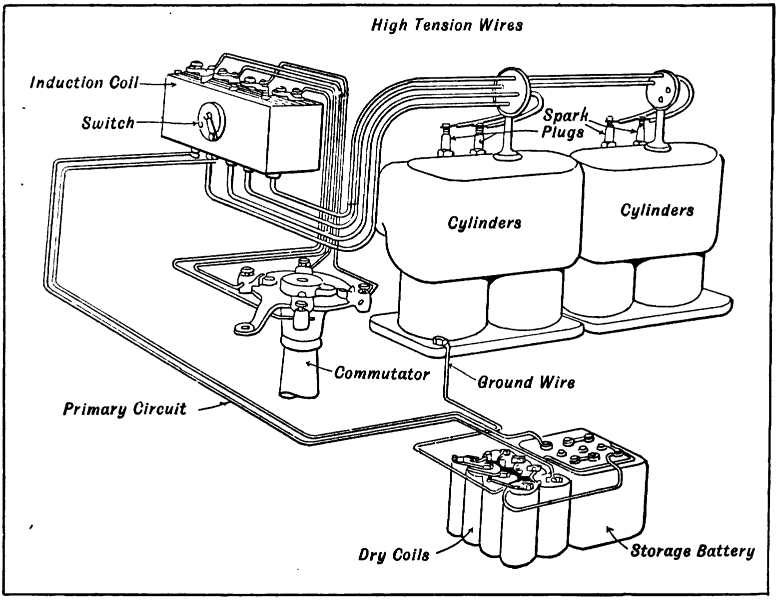


Fig. 55.—Assembly View of Four Cylinder Battery Ignition Group, Showing Devices and Methods of Wiring.

larger than the center V, which ends in a sharp point. This construction is said to cause the point to be self-cleaning by the explosion. Two electrodes pass through the insulating member instead of one, these being insulated from each other and the plug body as well. The high tension current enters one terminal and passes down one of the electrodes, jumps the air gap, and can only reach the ground if the terminal connected to the second electrode is in electrical connection with the terminal of an ordi-

nary form of spark plug or if it is bridged down to the plug body by the keeper B. When this keeper is in place, as indicated, the plug will act the same as a single electrode sparker. When the plug is to be used for double ignition in connection with one of the regular forms, the keeper B should be removed and a short

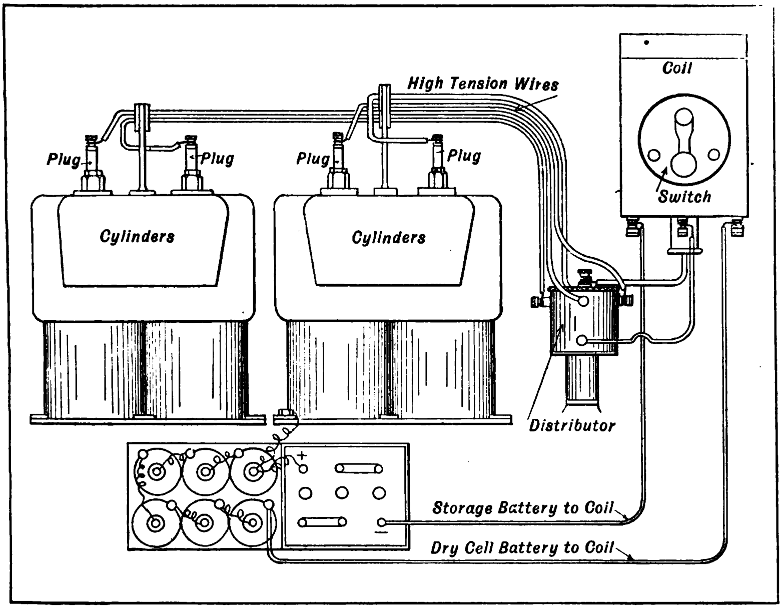


Fig. 56.—Method of Employing Single Vibrator Coil to Fire Four Cylinders when Secondary Current is Distributed Instead of Battery Energy.

wire used to join the terminal to which the keeper was attached to the terminal of the regular pattern spark plug.

Typical Battery Ignition Systems.—The components of typical battery ignition systems may be easily determined by studying the illustrations given at Figs. 55, 56 and 57. The four-cylinder ignition group shown at Fig. 55 depicts the conventional method of wiring two sets of batteries, a four-point timer or commutator, and a four-unit induction coil together. It will be seen that eight dry cells are wired together in series and are used as an auxiliary

to a six-volt or three-cell storage battery. The negative terminals of the storage battery and dry cell set are coupled together by a short length of wire and are grounded by being attached to the engine base by a suitable conductor. The positive terminals are coupled to the two binding posts under the switch or the coil. The four points of the commutator are attached to the different units of the coil while the secondary wires run from the high-

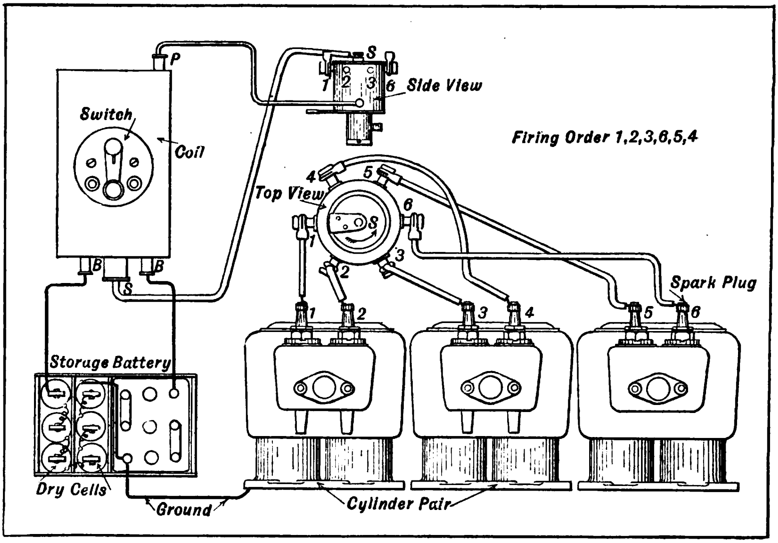


Fig. 57.—Distributor and Coil Ignition Group for Six Cylinder Motor, Showing Order of Firing and Wiring Connections.

tension terminals on the bottom of the coil to the spark plugs in the cylinders. If the switch lever is placed on one contact button, the current is obtained from the dry cells. If it is swung over to the other side, electricity from the storage battery is utilized.

A typical high-tension distributor system is shown at Fig. 56. Two sources of primary current are provided, one being a six-cell, dry battery, the other a three-cell, or six-volt storage battery. The battery connections are similar to those previously shown and but a single unit coil is needed to fire all cylinders. A single

primary wire is attached to the commutator section of the distributor. The secondary wire from the induction coil is joined to the distributing terminal on the top of the distributor, from which it is delivered to the collecting terminals spaced on quarters around the outer periphery of the distributor casing by means

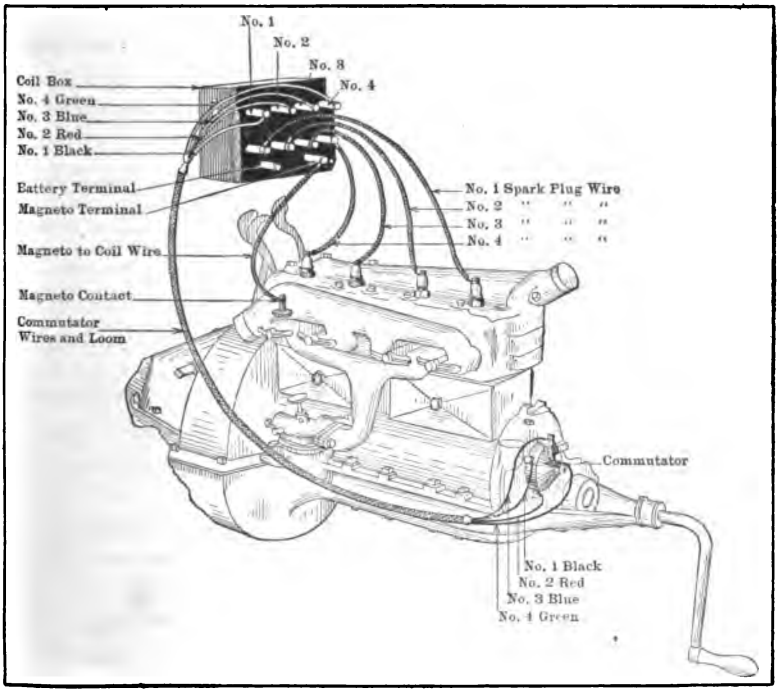


Fig. 58.—Complete Ford Magneto Ignition System, a Distinctive Method Found Only on This Car.

of a central distributing segment. Suitable conductors connect the distributor with the spark plugs in the cylinders.

The illustration at Fig. 57 is practically the same as that at Fig. 56, except that a distributor capable of firing a six-cylinder engine is used. If individual unit coils were to be employed, as is the case at Fig. 55, the coil box would contain six units and the

primary timer would have six contact points. The wiring would be considerably more complicated than the system outlined.

Master Vibrator Ignition Systems.—Practically the only car at the present time using the individual unit system of ignition is the Ford, the complete wiring diagram of which is clearly shown at Fig. 58, in the relation the parts actually occupy in the car. It will be observed that the induction coil has ten terminals, six of these being for the primary circuit and four for the secondary wires. The upper terminals of the coil are primary and run to the timer segments. The four secondary terminals are connected to the spark plugs as indicated, while the remaining two terminals, which are at the bottom of the coil, are joined to the magneto terminal and to the battery respectively. In the system outlined each coil has a separate vibrator.

Many Ford cars have been supplied with what is known as a master vibrator, which is a magnetic circuit breaker intended to perform that function for all of the coils. It is claimed that a device of this character produces synchronism of the ignition spark, which is not possible to obtain where four separate vibrators are used on account of some of these being tuned up faster than the others. It is contended that this makes a smoother-running engine and one delivering more power. A master vibrator unit that enjoys wide sale is of K-W manufacture and is designed especially for use with Ford cars. The method of wiring the vibrator is clearly outlined in the upper left hand corner at Fig. 59. As the vibrator unit carries a switch on its face, it has three terminals at the bottom, the center one of which is connected to one of the regular terminals of the spark coil, leaving the other one blank. One of the outside terminals of the master vibrator is coupled to the magneto, the other to a battery. The switch of the main coil is used only on one contact button, and may be left on that button, as the battery or magneto may be thrown in circuit at will by the switch on the master vibrator coil. It is necessary to short circuit the regular vibrators in order to put them out of commission. This is done by running a wire between the vibrator springs and the bridge carrying one of the contact points, as shown at the bottom of Fig. 59. Another method of short circuiting the vibrator is to

keep the points in contact by wedging a piece of wood, rubber or cardboard under the vibrator spring between the core of the coil and the vibrator. Keeping the points in contact in this manner is equivalent to short circuiting them by the wire shunt.

When but one vibrator is used the contact points must be made larger than those on the individual vibrators, because it does four times as much work. The construction of the K-W vibrator is

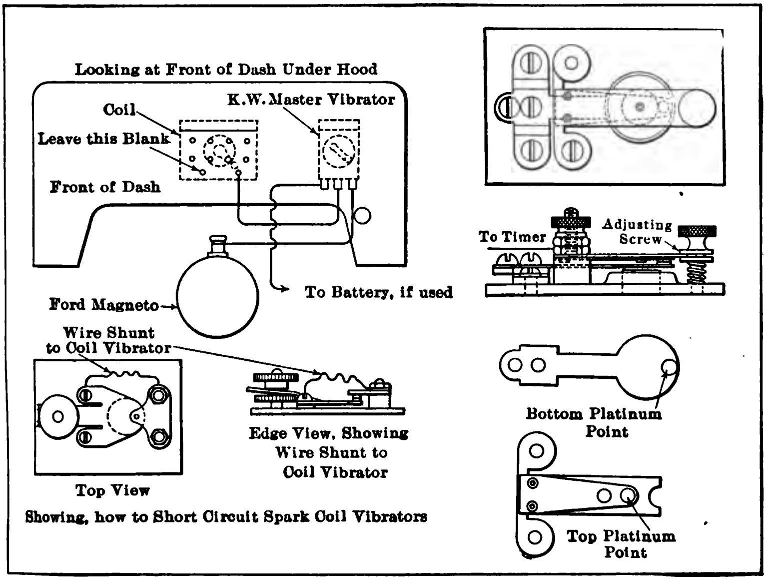


Fig. 59.—How Master Vibrator is Used.

clearly shown, and in view of the instructions that will be given for the care and adjustment of these devices it is not necessary to describe its construction. The instructions given for adjusting the vibrator are very simple, it being merely necessary to observe if there is a space of $\frac{1}{64}$ inch between the platinum contact points when the vibrator spring is held down firmly on the iron core. A gauge made of $\frac{1}{64}$ inch thick steel may be placed between the contact points until the adjusting screw is screwed down to a point where the gauge can be pulled out with-

out much trouble. This will give the proper distance for the armature or bottom spring to travel.

Non-vibrator Distributor Systems.—Because of the almost universal employment of electricity for lighting and starting systems, the battery ignition system has been improved materially inasmuch as the storage battery supplying the current is constantly charged by a generator. A number of systems has been devised, these operating on two different principles, the open circuit, such as the Atwater-Kent, previously described, and the closed circuit. An example of the close circuit system is shown at C, Fig. 60, and is of Connecticut design, the complete ignition system consisting of a combined timer and high tension distributor, a separate induction coil and a switch. The system is distinctive in that the timer is so constructed that the primary circuit of the coil is permitted to become thoroughly saturated with electricity before the points separate, with a result that a spark of maximum intensity is produced. The action is very much the same as that of a magneto on account of the saturation of the winding. Another feature is the incorporation with the switch of a thermostatically operated electro-magnetic device which automatically breaks the connection between the battery and the coil should the switch be left on with the motor idle.

The contact breaker mechanism consists of an arm A carrying one contact, a stationary block B carrying the other contact, a fiber roller R which is carried by the arm A and operated by points on the cam C, which is mounted on the driving shaft. Normally the contacts are held together under the action of a light spring. As the four cams, which in touching the roller R raise the arm and separate the contacts, are 90 degrees for a four-cylinder motor, the period of saturation of the coil or the length of time the current flows through it to the battery is sufficiently long so that when the points have separated the current which has "piled" up induces an intensely hot spark at the plugs. This is an advantage inasmuch as it insures prompt starting and regular ignition at low engine speed as well as providing positive ignition at high engine speed.

The thermostatic circuit breaking mechanism is very simple.

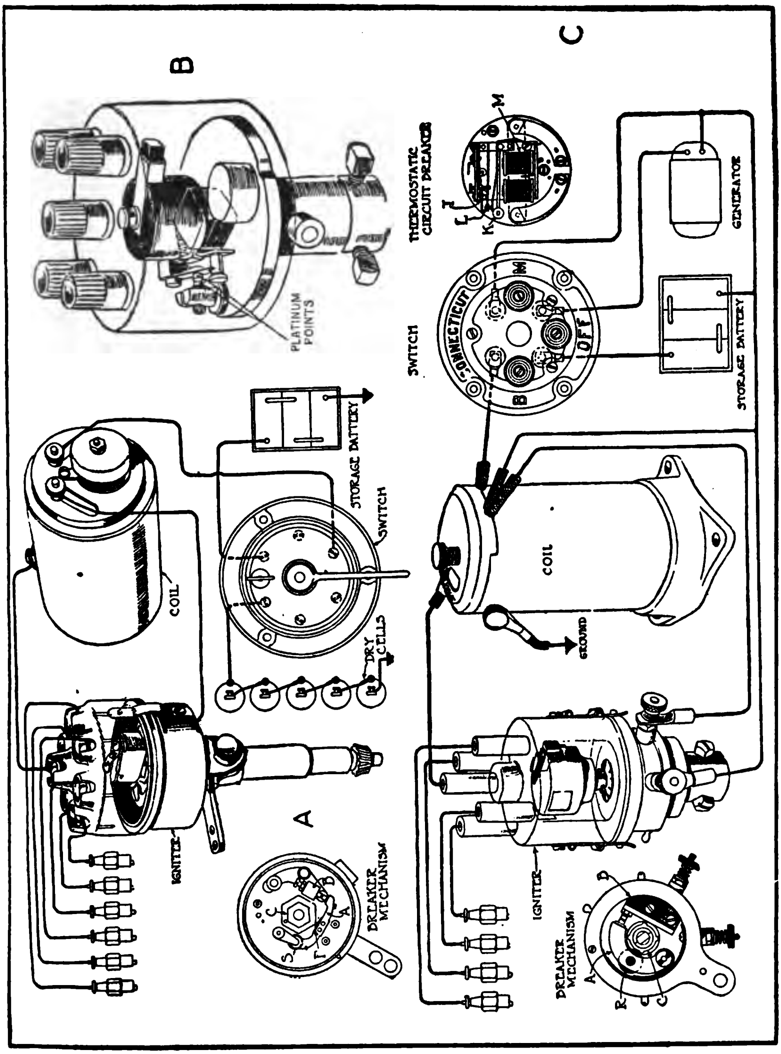


Fig. 60.—Typical Modern Battery Ignition Systems Outlined.

This consists of the thermostat T, which heats when the current passes through it for from thirty seconds to four minutes without interruption, and thus is bent downward, making contact with the contact L. This completes an electrical circuit which energizes the magnets M, causing the arm K to operate like the clapper in an electric bell. This arm strikes against the plate, which releases whichever of the two buttons in the switch may be depressed.

As will be observed, the transformer coil provided has five terminals. One of these is connected directly with the ground, the other leads to the central secondary distributing brush of the timer-distributor. Of the three primary leads, one goes to the switch, one to the wire leading from the storage battery to the timer, and one directly to a terminal on the timer. The switch is provided with three buttons, the one marked B being depressed to start the engine, as the ignition current is then drawn from the storage battery. After the engine has been started the button marked M is pressed in, this taking the current directly from the generator. To interrupt ignition the button "off" is pressed in, this releasing whichever of the buttons, B or M, is depressed. Four wires run from the distributor section of the igniter to the spark plug.

The 1916 Connecticut automatic ignition system, shown at Fig. 61, is considerably simplified and more compact than earlier types. The igniter housing now has a rounded top for the reception of the leads to the spark plugs, this form being an improvement over the flat top in that it provides no lodging place for moisture and dust, etc. At the same time, the housing which carries the distributor segments has been made lighter. The distributor arm also has been lightened and made more compact. Other improvements include the adoption of a new type of compression lock washer holding the cover plate over the breaker mechanism in place, and a new type of inclosed ball bearing at the lower end of the driving shaft. In principle, the new type of switch, which is in addition to the standard round type, is exactly like the older one except that it is mounted entirely behind the dash with nothing in view except a plate and four switch buttons. One of these serves to make the ignition circuit and another to break it. A

third button switches on head and tail lamp and the fourth button dims the head lamps for city driving. Any combination of lighting switches can be incorporated in the switch plate.

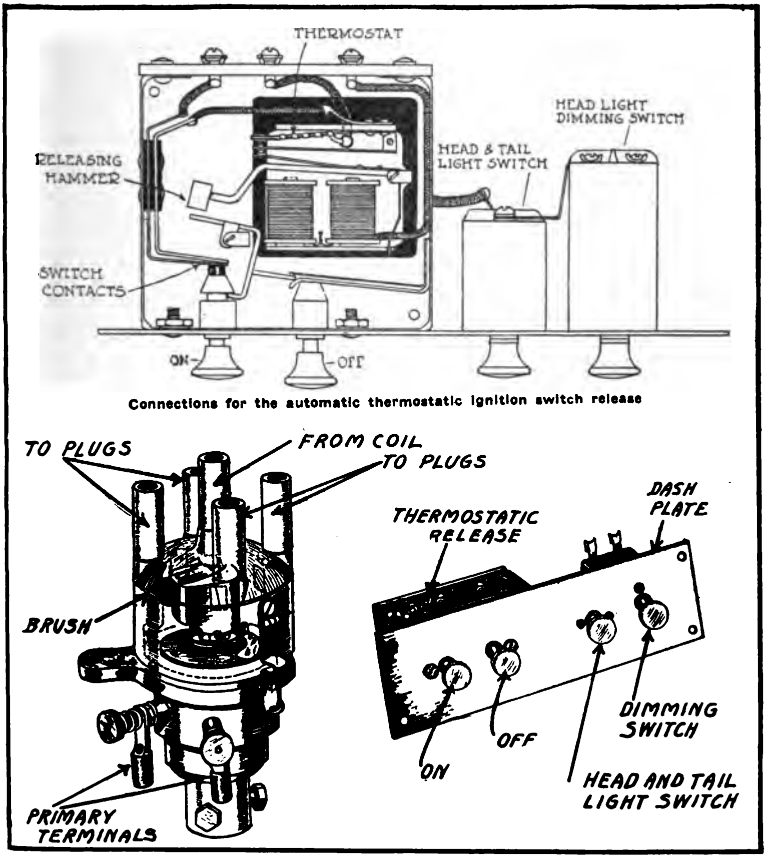


Fig. 61.—Illustrations Showing Construction of 1916 Connecticut Ignition System Timers and Thermostatically Controlled Switch.

When the ignition switch is closed, current drawn from the storage battery is caused to pass through a tiny thermostat on its way to the coil and thence to the distributor, and finally to the

plugs. If the motor is not started within a short time after the switch is closed—the length of time is easily adjustable—the thermostat closes a circuit through a tiny electric buzzer operating a releasing hammer which automatically opens the ignition circuit and thus prevents the battery draining itself. Obviously, if the motor is stalled and not again started, the thermostat will open the circuit in the same way. Thus, it is impossible for the motor to stand idle for more than a minute or so with the ignition switch closed. When the motor is running the amount of current passing through the thermostat is so small that it is negligible and has no effect.

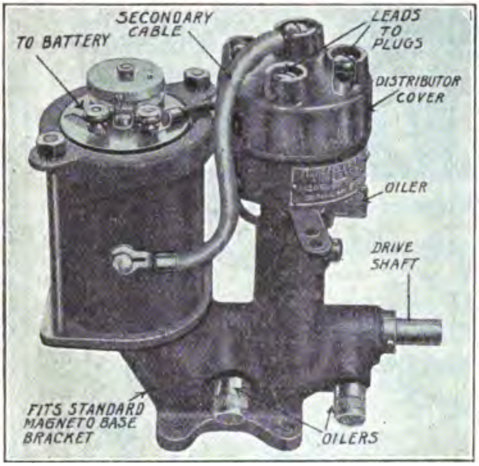


Fig. 62.—Remy Ignition Unit Designed to Fit Standard Magneto Base.

The Remy system also operates on the closed circuit principle and is shown at A, Fig. 60, in a form adapted for six-cylinder engine ignition. The transformer coil is of the three terminal type, one secondary going to the central secondary distributing brush of the timer while one primary is joined to the primary contact terminal of the timer portion of the igniter. The remaining coil terminal is joined to the switch. One of the poles of the storage battery and one of the series connected dry cell batteries are grounded, while from the other two the wires run to the switch contacts. The current may thus be derived either from the dry cell batteries for emergency or from the storage battery for regular ignition purposes. The construction of the timer which incorporates the breaker mechanism is clearly shown. The movable platinum contact point is carried by the arm A, which fulcrums on the bearing S, and which has a piece of hard steel F riveted

to it to act as a cam rider. The cam C is of hexagonal form, having six points which separate the contacts when they ride over the shoe F attached to the arm A. The fixed platinum contact point B is so arranged that it may be adjusted by moving in or out as conditions demand. It is to this member that the primary terminal of the coil is connected.

A typical combined timer distributor known as the Halladay is shown at B, Fig. 60. The make and break mechanism is very

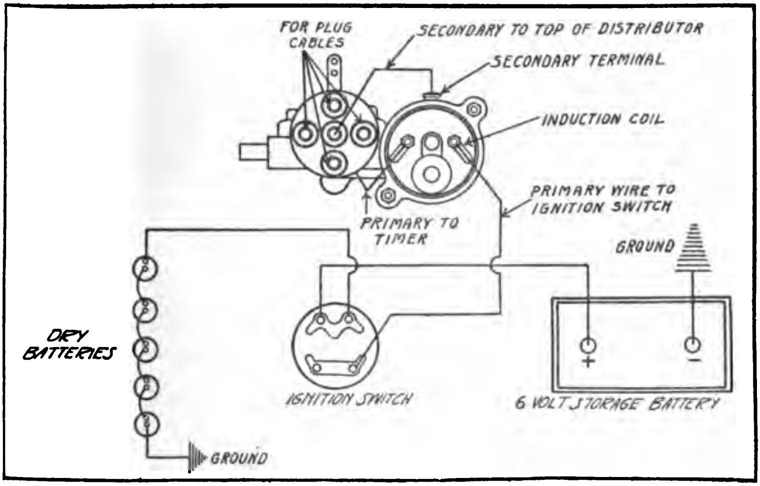


Fig. 63.—Wiring Diagram Showing Method of Connecting Remy Ignition Unit.

simple in design, as is the distributing mechanism. The contact between the platinum points is established by a four point cam. The secondary current is distributed from the central terminal to the four distributing terminals by a carbon brush very much similar in design to that employed in a high tension magneto. This operates on the open circuit principle. A complete ignition unit consisting of induction coil and timer-distributor of Remy design, so mounted that it will fit the standard magneto base and arranged so it can be driven in the same manner, is shown at Fig. 62. The wiring diagram of this igniter is outlined at Fig. 63. The induc-

tion coil and construction of distributor for six-cylinder engine ignition are depicted at Fig. 64. The Remy ignition system is sometimes incorporated in a combined ignition-generator, as shown in wiring diagram at Fig. 65.

Features of Low-Tension Ignition System.—Though the low-tension ignition system is seldom used at the present time, a brief description of the method of producing a make-and-break spark is desirable so the reader may gain a thorough knowledge of the

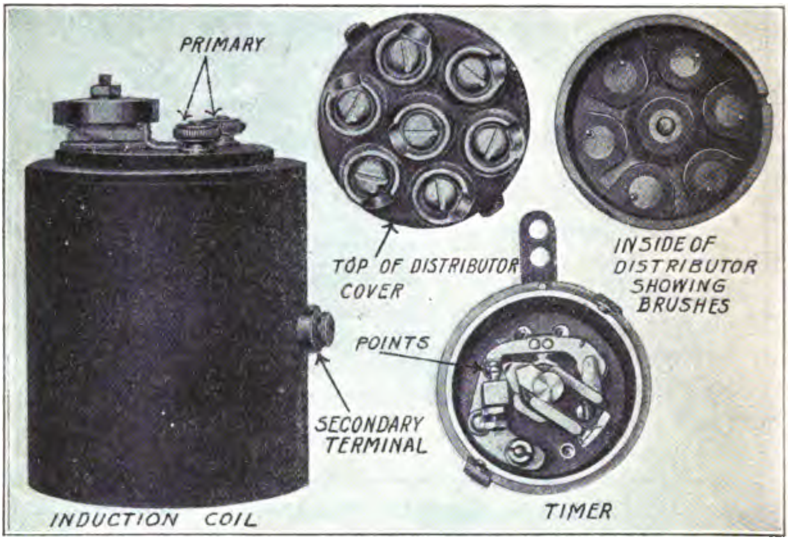


Fig. 64.—External View of Remy Induction Coil at Left and Parts of Timer-Distributor at Right.

methods of ignition in vogue. In order to obtain a spark in the cylinder of any engine, it is necessary that there be a break in the circuit and that this break or interruption be inside of the combustion chamber. The igniter plate used is different in construction from the spark plug forming part of the high-tension system, as the break is made by moving contacts which serve to time the spark as well as produce it.

A typical igniter is shown at A and B, Fig. 66. It consists of

a drop-forged plate approximately triangular in form which has a conical ground surface to fit a corresponding female member in the combustion chamber. It is secured by three bolts to a corner of the cylinder close to the inlet valve so the contact points will be traversed by the gases entering from the carburetor. As shown at B, the fixed contact point is called the anvil, while the movable

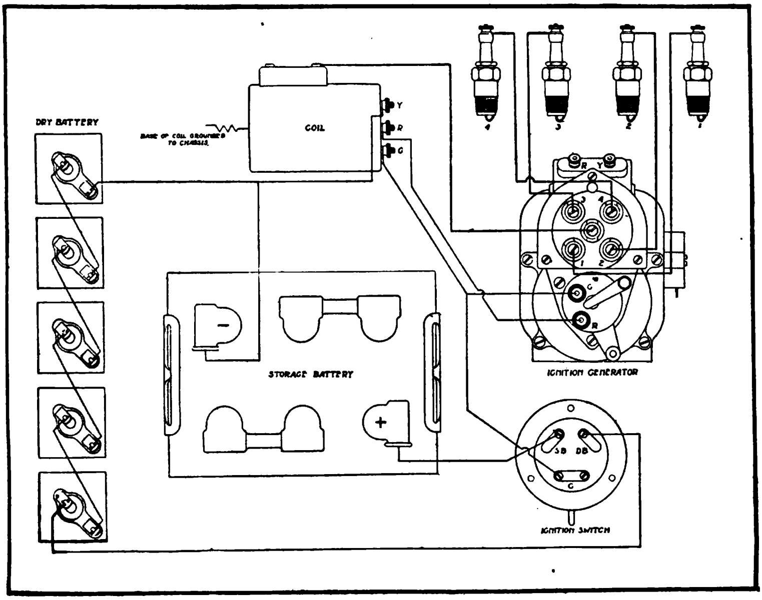


Fig. 65.—Wiring Diagram Showing Method of Connecting Remy Ignition Generator in Primary Circuit.

or rocking member is called the hammer. The anvil is insulated from the igniter plate by a bushing of mica or lava, and the hammer alternately makes and breaks contact with the anvil.

The method of actuating the hammer by a rocker arm is clearly shown at Fig. 67, B. The rocker arm H is in the form of a short lever ending in a slotted opening which is connected to the top of the vertical lifter rod T. This is actuated by a cam on the inlet valve cam shaft C, which raises the plunger in the guide

bushing. When the lifter rod moves upward the contact point on the hammer inside of the cylinder comes into contact with the platinum point on the anvil and closes the circuit. When the igniter cam reaches the proper point for igniting the charge the lifter rod T falls and as the action is quickened by a spring, S, 1, at the bottom of the lifter rod the hammer arm is separated from the contact point on the anvil and a spark takes place as the points are pulled apart.

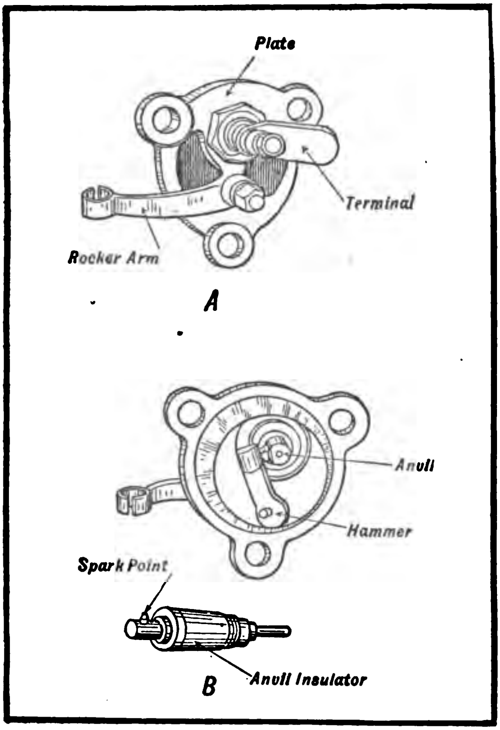


Fig. 66.—Construction of Locomobile Low Tension Igniter Plate.

The coil used when batteries are employed to furnish the current is a simple form. It is a winding of comparatively coarse wire around a core composed of a bundle of soft iron wire. The battery current is intensified to a certain extent by the self-induction of one layer of wire upon the others, and when contact is broken a brilliant spark occurs between the points of the igniter plate. Batteries are seldom used for regular service on the low-tension system because the demands are too severe.

One of the advantages of this system is that the wiring is extremely simple, as will be seen by consulting the diagram of the low-tension ignition system illustrated at Fig. 67, A. In this both a low-tension magneto and set of batteries are provided, the former

being used for regular ignition while the latter are carried for emergency service. A simple form of magneto will serve any number of cylinders because the insulated terminals of the igniters are joined together by a simple conductor or bus bar. A wire from the magneto terminal is joined to one side of the switch, while the other side of the switch is coupled to the coil which is carried in

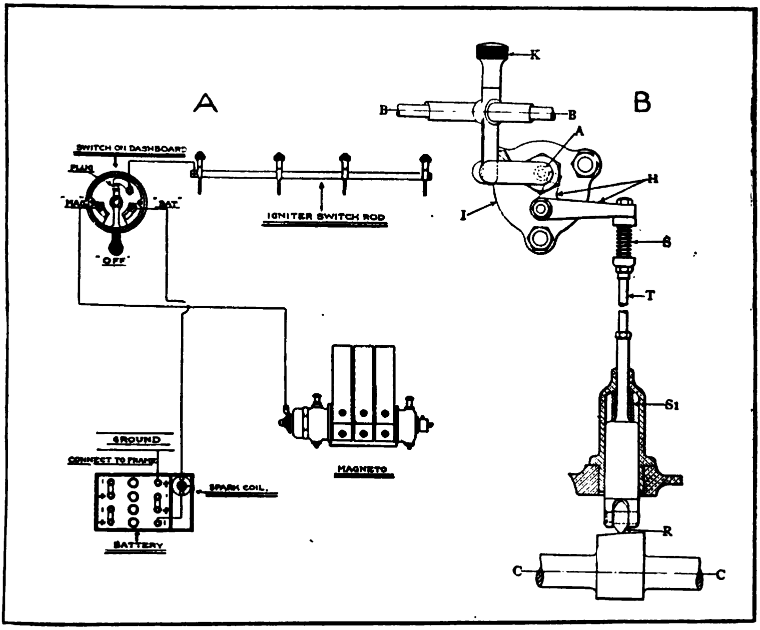


Fig. 67.—Diagram Showing Method of Operating Locomobile Low Tension Igniter.

the battery box. A short wire connects the top of the switch lever with the bus bar. If the switch lever is swung to the left, the magneto produces the current for the igniters, and if the switch lever is placed on the button at the right, the current supply is taken from the batteries. The dry cells are joined together in series connection, one pole being joined to a coil terminal, the other being grounded. The coil and the igniter plates are in series with the batteries and the current is returned to the

ground through the rocker arm, which is a metallic contact with the igniter plate.

The disadvantage which has militated against the general use of the make-and-break system of ignition is that it is very difficult to obtain synchronized spark after the mechanism has become worn, and unless the igniter plates are kept in perfect adjustment the spark time will vary and the efficiency of the engine will be lowered. As the moving electrodes operate under extremely disadvantageous conditions it is difficult to prevent rapid wear of the rocker arm bearing at the igniter plate and consequent leakage of gas results. Owing to the multiplicity of joints in the operating mechanism it is difficult to secure regular action without backlash or lost motion.

With a high-tension system there are no moving parts inside of the cylinder and it is not difficult to maintain a tight joint between the plug body and the cylinder head. The timer mechanism which is employed when batteries and coils are utilized to furnish the current is a comparatively simple device which is not liable to wear because it can be easily oiled and has a regular rotating movement which can operate without getting out of time much better than the reciprocating parts of the make-and-break mechanism. When a direct high-tension magneto is used the system is not much more complicated as far as wiring is concerned than a low-tension group, and as the ignition is more reliable it is not strange that jump spark or high-tension ignition is almost generally used in automobile practice.

Double and Triple Ignition Methods.—There are many cars in operation to-day which utilize double and triple ignition systems. On some of these it is possible to have three practically independent means of supplying the ignition spark. As will be apparent, the wiring of a triple ignition system is apt to be much more complex than that of the simpler methods now in vogue. In the ignition system outlined at Fig. 68, which has been used on a six cylinder car, it will be evident that in addition to the usual Bosch D-6 dual magneto an entirely independent individual spark coil and battery timer system is included. Two sets of plugs are used, one serving both magneto distributor systems, while the other

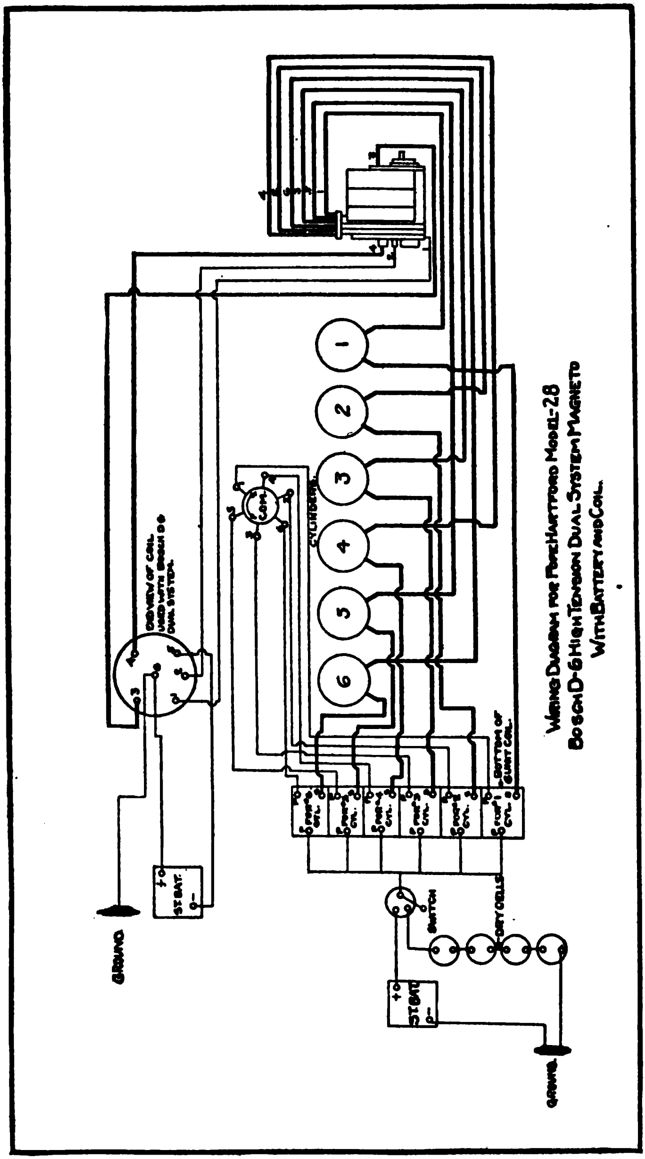


Fig. 68.—Diagram Showing Arrangement of Wiring of a Six Cylinder Engine Having Three Systems of Ignition.

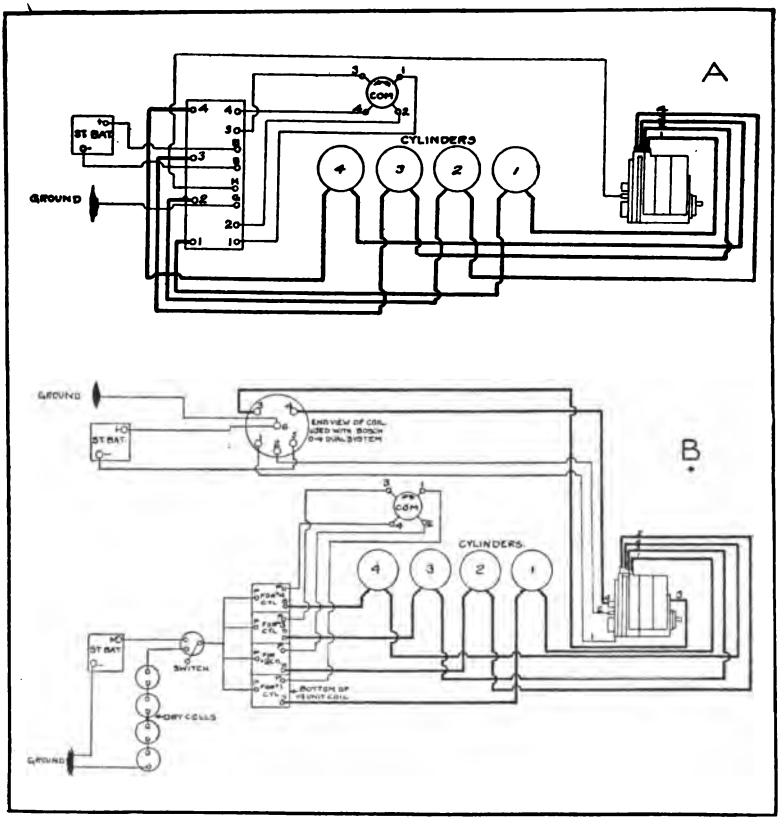


Fig. 69.—Wiring Diagram of Double Ignition System at A, of Triple Ignition System at B, Both for Four Cylinder Engines.

is connected to the individual coil units. The connections of the magneto system are no different than in the regular dual system previously described, while those of the battery and coil may be easily determined by a close study of the diagram. The primary timer has six contacts, one of which serves each ignition coil. As the firing order of this engine is 1-5-3-6-2-4, the wires from the timer must run to the individual unit coils in the same order so as to have the cylinders fire in proper sequence. For example, the wire from the contact No. 1 of the timer runs to coil No. 1,

next in order is contact No. 5, which is wired to coil unit No. 5. Following this comes timer contact No. 3, which supplies current to coil No. 3. While the individual spark coils are connected in order, i.e., coil No. 1 is joined to spark plug and cylinder No. 1, coil

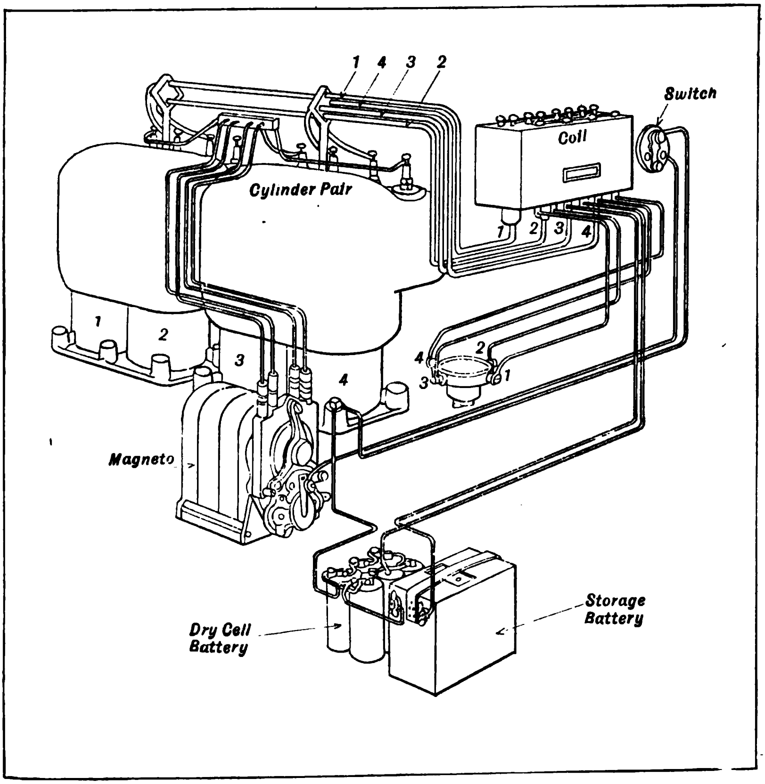


Fig. 70.—Practical Application of Double Ignition System to Four Cylinder Power Plant.

No. 2 to spark plug and cylinder No. 2, and so on the timer contact must be numbered according to the firing order. It will be apparent that two sources of ignition current are provided for the battery and coil systems, one being a storage battery, the other a set of dry cells.

A double ignition system in which a true high tension magneto is used and a four unit vibrator coil and four point timer is shown at A, Fig. 69. This ignition system is for a four-cylinder motor having a firing order of 1-3-4-2. At B, Fig. 69, a triple ignition system for a four-cylinder engine is shown, this being practically the same as that outlined at Fig. 68 except that the wiring diagram is somewhat simpler owing to the lesser number of cylinders. The advantage of a double ignition system is that one can determine if irregular engine operation is due to the ignition system or not very easily by running the engine first on one system, then on the other. If the engine runs as it should on the battery system after it has been misfiring on the magneto it is reasonable to assume that some portion of the magneto system is not functioning properly. If the engine runs well on the magneto, but not on the battery, the trouble may be ascribed to failure in the chemical current producer or its auxiliary devices. On the other hand, if the engine does not run well on either ignition systems, it is fair to assume that the trouble is not due to faulty ignition. A non-technical illustration of one of the double ignition systems that were prominent before the general adoption of self-starters and when the high-tension magneto was not yet accepted without suspicion is shown at Fig. 70.

Battery Ignition System Troubles.—Ignition troubles are usually evidenced by irregular engine action. The motor will not run regularly nor will the explosions follow in even sequence. There may be one cylinder of a multiple cylinder motor that will not function at all, in which case the trouble is purely local, whereas if all the cylinders run irregularly there is some main condition outside of the engine itself that is causing the trouble. The first point to examine is the source of current. Full instructions for the care and repair of storage batteries are given in following pages so we will first consider the simple primary or dry cells. It will be observed that a dry cell is very simple in construction and that nothing is apt to occur that will reduce its capacity except diminution in the strength of the electrolyte or eating away of the zinc can by chemical action. The elements in a dry cell are usually combined in such proportions that about the time the electrolyte

is exhausted, the zinc can will also have outlived its usefulness. It is much cheaper to replace dry cells with new ones than to attempt to repair the exhausted ones.

Evaporation of the electrolyte is the main cause of deterioration of dry cells as the internal resistance of the cell increases when

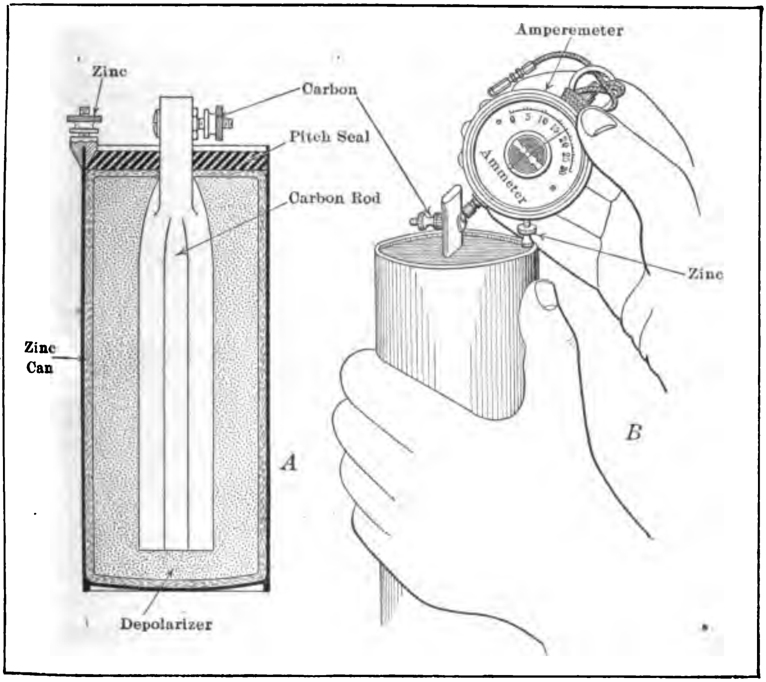


Fig. 71.—View at A, Showing Internal Construction of Dry Cell Battery. B—Method of Testing Dry Cells with Amperemeter.

the moisture evaporates. It is said that dry cells will depreciate even when not in use, so it is important for the repairman to buy these only as needed and not to keep a large stock on hand. In order to test the capacity of a dry cell an amperemeter is used as indicated at Fig. 71, B. Amperemeters are made in a variety of forms, some being combined with volt meters. The combination instrument is the best form for the repairman to use as the volts

scale can be employed for testing storage batteries while the ampere scale may be utilized in determining the strength of dry cells. A fully charged, fresh dry cell should show a current output of from twenty to twenty-five amperes. If the cell indicates below six or seven amperes, it should be discarded as it is apt to be exhausted to such a point that it will not furnish current enough to insure energetic or reliable ignition. Dry cells

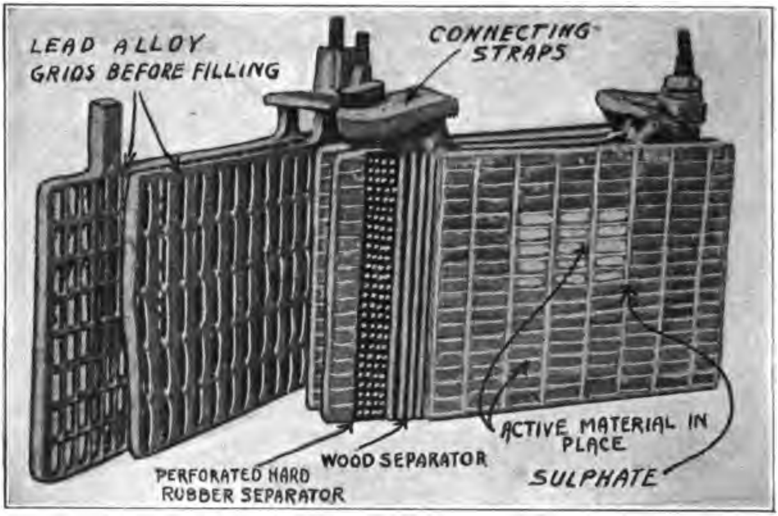


Fig. 72.—Showing Construction of Storage Battery Plates. Grids at Left of Illustration are Not Filled with Active Material in Order to Clearly Show Skeleton of Plate.

should always be stored in a cool and dry place, so that the electrolyte will not evaporate. If moisture is given an opportunity to collect on the top of the pitch seal it will allow a gradual loss of current due to short circuiting the cells. In applying an amperemeter, care should be taken to always connect the positive terminal marked with a plus sign against the carbon terminal. In the indicating meter shown at B, it is necessary to use only one contact point which is pressed against the screw passing through the carbon rod. The case of the instrument is placed in contact

with the zinc terminal to complete the circuit. A flexible wire is usually included in order to test the amperage of a group of cells should this be thought necessary. When dry cells are used for automobile ignition, they should be carefully packed in a box made of non-conducting material, such as wood, and securely covered so there will be no chance for water to enter the container. If placed in a sheet metal case, care should be taken to line the box with insulating material and also to pack the cells tightly so they cannot shake around. The best practice is to use wedges or blocks of wood which are driven in between the cells to keep them apart. In no case should a dry cell be placed directly in a steel box, as the binding posts on the zincs might come in contact with the walls of the box and tend to short circuit the cells, producing rapid depreciation. A battery box should always be placed at a point where it is not apt to be drenched with water when the car is washed or should be watertight if exposed.

Storage Battery Defects.—The subject of storage battery maintenance was thoroughly covered in a paper read by H. M. Beck before the S. A. E. and published in the transactions of the society. Some extracts from this are reproduced in connection with notes made by the writer and with excerpts from instruction books of battery manufacturers in order to enable the reader to secure a thorough grasp of this important subject without consulting a mass of literature. Endeavor has been made to simplify the technical points involved and to make the exposition as brief as possible without slighting any essential points. In view of the general adoption of motor starting and lighting systems on all modern automobiles, the repairman or motorist must pay more attention to the electrical apparatus than formerly needed when the simple magneto ignition system was the only electrical part of the automobile. The storage battery is one of the most important parts of the modern electrical systems and all up-to-date repairmen must understand its maintenance and charging in order to care for cars of recent manufacture intelligently.

A storage battery, from an elementary standpoint, consists of two or more plates, positive and negative, insulated from each

other and submerged in a jar of dilute sulphuric acid. The plates consist of finely divided lead, known as the active material, held in grids which serve both as supports and as conductors for the active material as at Fig. 72. The active material being finely divided, offers an enormous surface to the electrolyte and thus

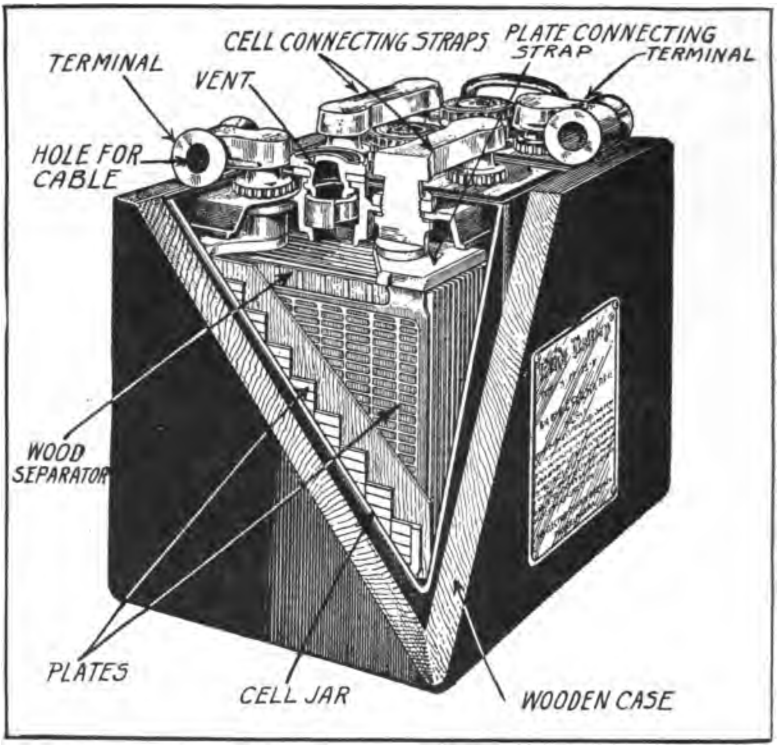


Fig. 73.—Part Sectional View, Showing Construction of Exide Starting and Lighting Battery.

electro-chemical action can take place easily and quickly. Two plates such as described, would have no potential difference, the active material of each being the same. If, however, current from an outside source is passed between them, one, the positive, will become oxidized, while the other remains as before, pure lead. This

combination will be found to have a potential difference of about two volts, and if connected through an external circuit, current will flow.

During discharge, the oxidized plate loses its oxygen and both plates will become sulphated until, if the discharge is carried far enough, both plates will again become chemically alike, the active material consisting of lead sulphate. On again charging, the sulphate is driven out of both plates and the positive plate oxidized and this cycle can be repeated as often as desired until the plates are worn out. Thus charging and discharging simply result in a chemical change in the active material and electrolyte, and the potential difference between the plates and capacity is due to this change.

In taking care of a storage battery, there are four points which are of the first importance:

First—The battery must be charged properly.

Second—The battery must not be overdischarged.

Third—Short circuits between the plates or from sediment under them, must be prevented.

Fourth—The plates must be kept covered with electrolyte and only water of the proper purity used for replacing evaporation.

In the event of electrical trouble which may be ascribed to weak source of current, first test the battery, using a low reading voltmeter. Small pocket voltmeters can be purchased for a few dollars and will be found a great convenience. Cells may be tested individually and as a battery. The proper time to take a reading of a storage battery is immediately upon stopping or while the engine is running. A more definite determination can be made than after the battery has been idle for a few hours and has recuperated more or less. A single cell should register more than two volts when fully charged, and the approximate energy of a three-cell battery should be about 6.5 volts. If the voltage is below 6 volts the batteries should be recharged and the specific gravity of the electrolyte brought up to the required point. If the liquid is very low in the cell new electrolyte should be added. To make this fluid add about one part of chemically pure sulphuric acid to about four parts of distilled water, and add more

water or acid to obtain the required specific gravity, which is determined by a hydrometer. According to some authorities the hydrometer test should show the specific gravity of the electrolyte as about 1.208 or 25 degrees Baumé when first prepared for introduction in the cell, and about 1.306 or 34 degrees Baumé when the cell is charged.

The appended conversion formula and table of equivalents will be found of value in changing the reading of a hydrometer, or acidometer, from terms of specific gravity to the Baumé scale, or vice versa.

$$\text{Sp. Gr.} = \frac{145}{145 - \text{Baumé degrees}} \text{ at } 60° \text{ F.}$$

The following table gives the corresponding specific gravities and Baumé degrees:

Baumé	Specific Gravity	Baumé	Specific Gravity
0	1.000	18	1.141
1	1.006	19	1.150
2	1.014	20	1.160
3	1.021	21	1.169
4	1.028	22	1.178
5	1.035	23	1.188
6	1.043	24	1.198
7	1.050	25	1.208
8	1.058	26	1.218
9	1.066	27	1.228
10	1.074	28	1.239
11	1.082	29	1.250
12	1.090	30	1.260
13	1.098	31	1.271
14	1.106	32	1.283
15	1.115	33	1.294
16	1.124	34	1.306
17	1.132	35	1.318

Either voltage or gravity readings alone could be used, but as both have advantages in certain cases, and disadvantages in others, it is advisable to use each for the purpose for which it

is best fitted, the one serving as a check on the other. Voltage has the great disadvantage in that it is dependent upon the rate of current flowing. Open circuit readings are of no value, as a cell reads almost the same discharged as it does charged. On the other hand, a voltmeter is a very easy instrument to read and may be located wherever desirable. Specific gravity readings are almost independent of the current flowing, but the hydrometer is difficult to read, not very sensitive and the readings must be taken directly at the cells.

Charging the Storage Battery.—Great care should be used in charging and the charging rates given by the various manufacturers should be followed whenever possible. It is essential that the positive wire carrying the charging current be connected with the positive plates of the battery. The positive pole of a cell is usually indicated by a plus sign or by the letter "P." In case of doubt always ascertain the proper polarity of the terminals before charging. This is done by immersing the ends in acidulated water, about an inch apart. The one around which the more bubbles collect is the negative, and should be connected with negative pole of the battery. If a cell is not connected properly it will be ruined. A battery always should be charged, if possible, at a low charging rate, because it will overheat if energized too rapidly. The normal temperature is between 70 and 90 degrees Fahrenheit. When the battery is fully charged the solution assumes a milky white appearance and bubbles of gas are seen rising to the surface of the electrolyte. All foreign matter should be kept out of the batteries as any metallic substance finding its way into the cell or between the terminals will short circuit the cell and perhaps ruin it before its presence is known. The terminals, the outside of the cell and all connections, should be kept free from acid or moisture. A neglect of these essentials means corrosion and loss of capacity by leakage. There is one point in connection with the charge which should be especially emphasized, namely, that the final voltage corresponding to a full charge is not a fixed figure, but varies widely, depending upon the charging rate, the temperature, the strength of the electrolyte, and age of the battery. For this reason, charging to a fixed volt-

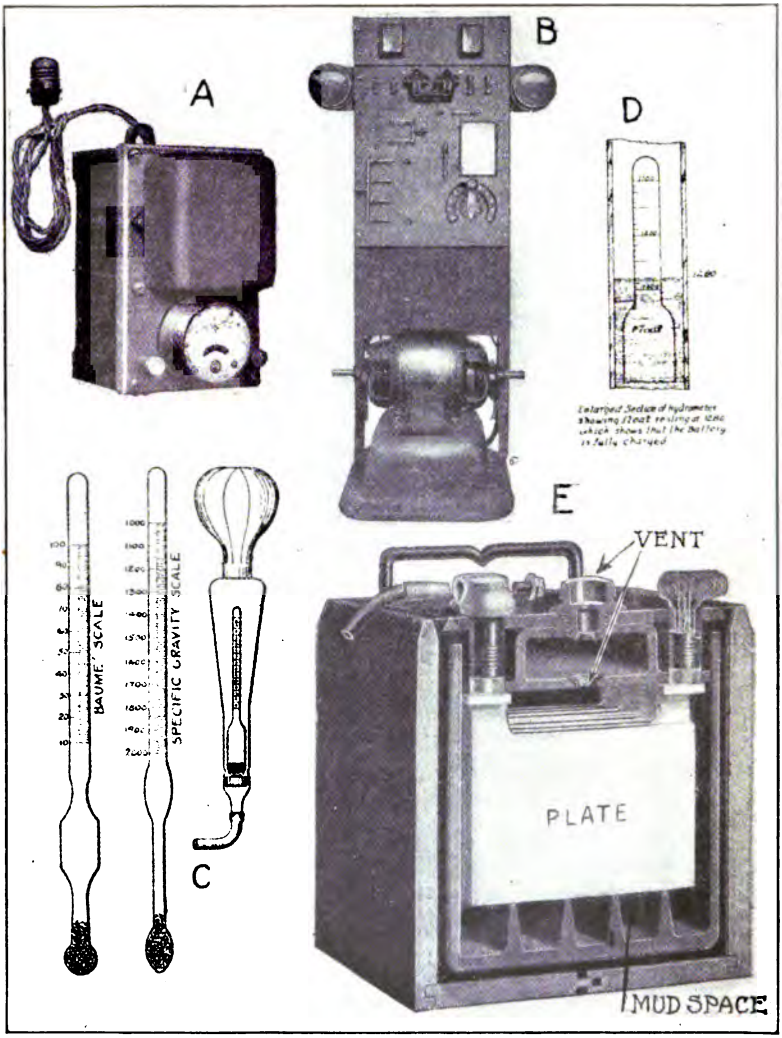


Fig. 74.—Appliances for Charging and Testing Storage Batteries.

age is unreliable and likely to result disastrously. The charge should be continued until the voltage or gravity ceases rising, no matter what actual figures are reached. Old cells at high tempera-

tures may not go above 2.4 volts per cell, whereas if very cold, they have been known to run up to three volts.

The points to be especially emphasized in connection with the charge are:

First—On regular charges keep the rates as low as practical and cut off the current promptly. It is preferable to cut off a

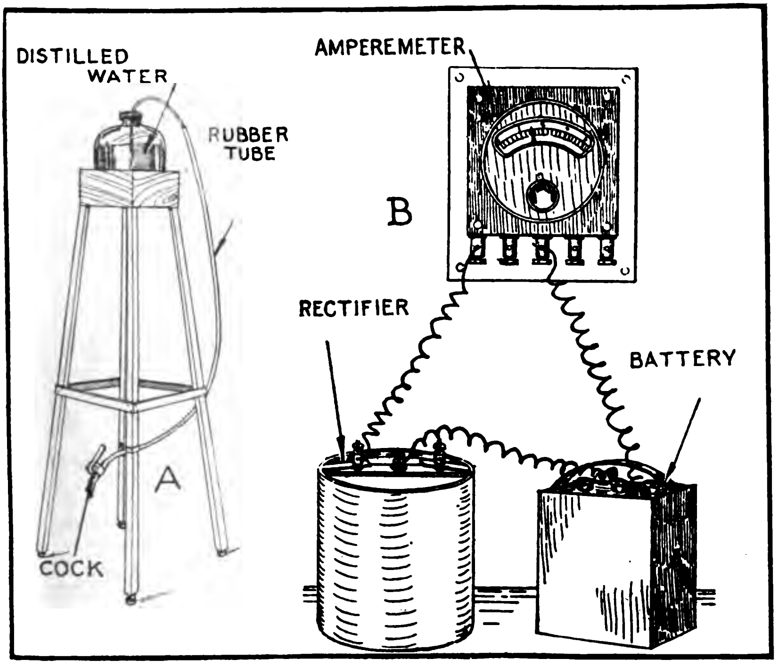


Fig. 75.—Stand Shown at A Facilitates Filling Cells with Distilled Water. Rectifier at B Charges Storage Battery from Alternating Current.

little too soon rather than to run too long where there is any question.

Second—Overcharges must be given at stated intervals and continued to a complete maximum. They should be cut off at the proper point, but when in doubt it is safer to run too long, rather than to cut off too soon.

Third—Do not limit the charge by fixed voltage.

Fourth—Keep the temperature within safe limits.

Fifth—Keep naked flames away from cells while charging as the gas given off is inflammable. Always see that gas vents are clear before charging.

The following table will undoubtedly be of value as a guide to the proper charging rates of batteries of various ampere hour capacities, the assumption being that these are all 3 cell batteries that will show between 6.5 and 7.5 volts when fully charged. While most manufacturers of batteries furnish instruction books, these may be lost, so some compact reference is needed. The overall dimensions of the batteries are given so the capacity may be determined even if the marks of identification on the name plate are obliterated

TABLE OF CHARGING RATES

Elba Lighting Batteries

Type.	Normal Charging Rates. Amp. Required.		24-Hr. Charging Rate	Volts per Cell at End of Charge at 24-Hr. Rate	Volts of Battery at End of Charge at 24-Hr. Rate	Size of Battery Over all			No. of Cells
	Start	Finish				Length in in.	Width in in.	Height in in.	
ELB—60-90.......	9	3	3	2½	½	10⅜	7½	9½	3
ELB—80-120......	12	4	4	2½	7½	11½	7½	9½	3
ELB—100-150.....	15	5	5	2½	7½	12⅞	7½	9½	3
ELB—120-180.....	18	6	6	2½	7½	15⅜	7½	9½	3
HSB—60-90.......	9	3	3	2½	7½	9¾	6	10	3
HSB—80-120......	12	4	4	2½	7½	11	6	10¾	3
HSB—100-150.....	15	5	5	2½	7½	12⅜	6	10¾	3
HSB—120-180.....	18	6	6	2½	7½	15	6	10¾	3
PAB—120-180.....	18	6	6	2½	7½	10⅛	7½	14¼	3

A battery may be charged from any source of direct current. Garages, central stations, lighting plants, etc., can do the work, and in many instances where direct current is used for power

purposes, a simple charging outfit is operated from the dynamo. Where alternating current only is available, a rectifier which changes alternating current to direct current may be installed and the battery charged with no inconvenience and at comparatively small cost. All of these methods will be considered in proper sequence and typical charging outfits described.

Remedies for Loss of Battery Capacity.—When a battery gives indication of lessened capacity it should be taken apart and the trouble located. If the cell is full of electrolyte it may be of too low specific gravity. The plates may be sulphated, due to lack of proper charge or too long discharge. The cells may need cleaning, a condition indicated by short capacity and a tendency to overheat when charging. Sometimes a deposit of sediment on the bottom of the cell will short circuit the plates. If the specific gravity is low and the plates have a whitish appearance, there being little sediment in the cells, it is safe to assume that the plates are sulphated. Sediment should be removed from the cells and the plates rinsed in rain or distilled water to remove particles of dirt or other adhering matter.

The rate at which the sediment collects, depends largely upon the way a battery is handled and it is, therefore, necessary to determine this rate for each individual case. A cell should be cut out after say fifty charges, the depth of sediment measured and the rate so obtained, used to determine the time when the battery will need cleaning. As there is apt to be some variation in the amount of sediment in different cells, and as the sediment is thrown down more rapidly during the latter part of a period than at the beginning, it is always advisable to allow at least one-fourth inch clearance. If the ribs in the bottom of the jars are 1¾ inches high, figure on cleaning when the sediment reaches a depth of 1½ inches. Before dismantling a battery for "washing," if practical, have it fully charged. Otherwise, if the plates are badly sulphated, they are likely to throw down considerable sediment on the charge after the cleaning is completed

There have been many complaints of lack of capacity from batteries after washing. Almost without exception this is found to be due to lack of a complete charge following the cleaning.

The plates are frequently in a sulphated condition when dismantled and in any case are exposed to the air during the cleaning process, and thus lose more or less of their charge. When re-assembled, they consequently need a very complete charge, and in some cases the equivalent of the initial charge, and unless this charge is given, the cells will not show capacity and will soon give trouble again. This charge should be as complete as that described elsewhere in connection with the initial charge.

"Flushing" or replacing evaporation in cells with electrolyte instead of water, is a most common mistake. The plates of a storage battery must always be kept covered with electrolyte, but the evaporation must be replaced with pure water only. There seems to be a more or less general tendency to confuse the electrolyte of a storage battery with that of a primary cell. The latter becomes weakened as the cell discharges and eventually requires renewal. With the storage battery, however, this is not the case, at least to anything like the same degree, and unless acid is actually lost through slopping or a broken jar, it should not be necessary to add anything but water to the cells between cleanings. Acid goes into the plates during discharge, but with proper charging it will all be driven out again so that there will be practically no loss in the specific gravity readings, or at least one so slight that it does not require adjustment between cleanings. Thus, unless some of the electrolyte has actually been lost, if the specific gravity readings are low, it is an indication that something is wrong, but the trouble is not that the readings are low, but that something is causing them to be low, and the proper thing to do is to remove the cause and not try to cover it up by doctoring the indicator. The acid is in the cells and if it does not show in the readings, it must be in the form of sulphate, and the proper thing to do is to remove the cause of the sulphation if there is one, and then with proper charging, drive the acid out of the plates and the specific gravity readings will then come back to the proper point. The too-frequent practice in such cases is to add electrolyte to the cells in order to bring up the readings, which as already explained, are only the indication of the trouble, and this further aggravates the condition, until finally the plates be-

come so sulphated that lack of capacity causes a complaint. This practice of adding electrolyte to cells instead of water, seems to be coming more and more common.

If there is any doubt about the polarity of the plates when reassembling after cleaning it is well to note that the positive plate is chocolate in color and the negative is gray.

When plates are sulphated, to restore them to their original condition it is necessary that the battery be given a long, slow charge at about a quarter or a third of the normal charging rate. This should be continued until the electrolyte has reached the proper specific gravity and the voltage has attained its maximum.

It should be understood that sulphating is a normal as well as an abnormal process in the charge and discharge of storage batteries, and the difference is in the degree, not the process. The abnormal condition is that ordinarily referred to by the term. In normal service sulphating does not reach the point where it is difficult to reduce, but if carried too far, the condition becomes so complete that it is difficult to reduce, and injury results. A very crude method of illustrating the different degrees of sulphating is to consider it as beginning in individual particles uniformly distributed throughout the active material. Each particle of sulphate is then entirely surrounded by active material. The sulphate itself is a non-conductor, but being surrounded by active material, the current can reach it from all sides and it is easily reduced. This is normal sulphate. As the action goes further the particles of sulphate become larger and join together and their outside conducting surface is greatly reduced in comparison with their volume so that it becomes increasingly difficult to reduce them and we have abnormal sulphate.

The general cure for sulphating is charging, so that a cell having been mechanically restored, the electrical restoration consists simply in the proper charging. Sulphate reduces slowly and on this account it is a good plan to use a rather low current rate. High rates cause excessive gassing, heating and do not hasten the process appreciably, so that it is the safer as well as the more efficient plan to go slowly. A good rate is about one-fifth normal. The length of charge will depend upon the degree of sulphating.

In one actual case it required three months' charging night and day to complete the operation, but this was, of course, an exceptional one. The aim should be to continue until careful voltage and gravity readings show no further increase for at least ten hours and an absolute maximum has been reached. In serious cases it may be advisable to even exceed this time in order to make absolutely sure that all sulphate is reduced, and where there is any question it is much safer to charge too long, rather than to risk cutting off too soon. A partial charge is only a temporary expedient, the cell still being sulphated will drop behind again.

Battery Charging Apparatus.—The apparatus to be used in charging a storage battery depends upon the voltage and character of the current available for that purpose. Where direct current can be obtained the apparatus needed is very simple, consisting merely of some form of resistance device to regulate the amperage of the current allowed to flow through the battery. The internal resistance of a storage battery is very low and if it were coupled directly into a circuit without the interposition of additional resistance an excessive amount of current would flow through the battery and injure the plates. When an alternating current is used it is necessary to change this to a uni-directional flow before it can be passed through the battery. Alternating current is that which flows first in one direction and immediately afterward in the reverse direction. When used in charging storage batteries some form of rectifier is essential. The rectifier may be a simple form as shown at Fig. 74, A, which is intended to be coupled directly into a lighting circuit by screwing the plug attached to the flexible cord in the lamp socket. A rotary converter set such as shown at B, may also be used, in this the alternating current is depended on to run an electric motor which drives the armature of a direct current dynamo. The current to charge the battery is taken from the dynamo, as it is suitable for the purpose, whereas that flowing through the motor cannot be used directly.

The view at Fig. 74, C, shows a usual form of hydrometer-syringe which is introduced into the vent hole of the storage battery such as shown at E and enough electrolyte drawn out of the cell to determine its specific gravity. This is shown on the hydrom-

eter scale as indicated in the enlarged section at D. A very useful appliance where considerable storage battery work is done is shown at Fig. 75, A. This is a stand of simple form designed to carry a carboy containing either acid, distilled water, or electrolyte. In fact, it might be desirable to have three of these stands, which are inexpensive, one for each of the liquids mentioned. In many repair shops the replenishing of storage batteries is done in a wasteful manner as the liquid is carried around in a bottle or old water pitcher and poured from that container into the battery, often without the use of a funnel. The chances of spilling are, of course, greater than if the liquids were carefully handled and more time than necessary is consumed in doing the work. The stand shown is about 5 feet high and is fitted with castors so it may be easily moved about the shop if necessary. For example, in taking care of electric vehicle batteries it may be easier to move the carboy to the battery than to remove the heavy battery from the automobile. The container for the liquid is placed on top of the stand and the liquid is conveyed from it by a rubber tube. The rubber tube is attached to a glass tube extending down nearly to the bottom of the liquid. At the bottom of the rubber tube an ordinary chemist's clip which controls the flow of liquid is placed. In order to start a flow of liquid it is necessary to blow into a bent glass vent tube which is also inserted into the stopper. Once the rubber tube has become filled with liquid merely opening the clip will allow the liquid to flow into the battery as desired.

In most communities the incandescent lighting circuit is used for charging batteries on account of the voltage of the power circuits being too high. The incandescent lighting circuit may be any one of six forms. A direct current of either 110 or 220 volts used over short distances, either 220 or 440 volts on three wire circuits over long distances, alternating current at a constant potential, usually 110 volts and in various polyphase systems. It might be stated that in the majority of instances house and garage lighting circuits furnish direct current of 110 volts. We will consider the devices used with the alternating form, one of which is shown at Fig. 75, B. This is known as the Rollinson electrolytic rectifier which is based upon the following principles: When an

element of aluminum and a corresponding element or plate of iron are submerged in a solution of certain salts, using these elements as negative and positive terminals, respectively, the passage of an electric current through the solution produces a chemical action which forms hydroxide of aluminum. A film of hydroxide thus formed on the aluminum element repels the current. The arrangement of the cell will then permit current to pass through it in one direction only, the film of chemical preventing it from passing in the opposite direction. The result is that if an alternating current is supplied to the cell a direct pulsating current can be obtained from it. The outfits usually include a transformer for reducing the line voltage to the lower voltages needed for battery charging purposes. Regulation of the current is effected in the simplest type by immersing the elements more or less in the solution in the jar. As complete instructions are furnished by the manufacturers it will not be necessary to consider this form of rectifier in detail.

One of the most commonly used rectifying means is the mercury arc bulb. This device is a large glass tube of peculiar shape, as shown at Figs. 76 and 77, which contains in the base a quantity of mercury. On either side of this lower portion two arms of the glass bulbs extend outwardly, these being formed at their extremities into graphite terminals or anodes indicated as A and A-1, Fig. 77. The current from the auto transformer is then attached one to each side. The base forms the cathode or mercury terminal for the negative wires. The theory of this action is somewhat complicated, but may be explained simply without going too much into detail. The interior of the tube is in a condition of partial vacuum and while the mercury is in a state of excitation a vapor is supplied. This condition can be kept up only as long as there is a current flowing toward the negative. If the direction of the current be reversed so that the formerly negative pole becomes a positive the current ceases to flow, as in order to pass in the opposite direction it would require the formation of a new cathode element. Therefore the flow is always toward one electrode which is kept excited by it. A tube of this nature would cease to operate on alternating current voltage after half a cycle if some means were

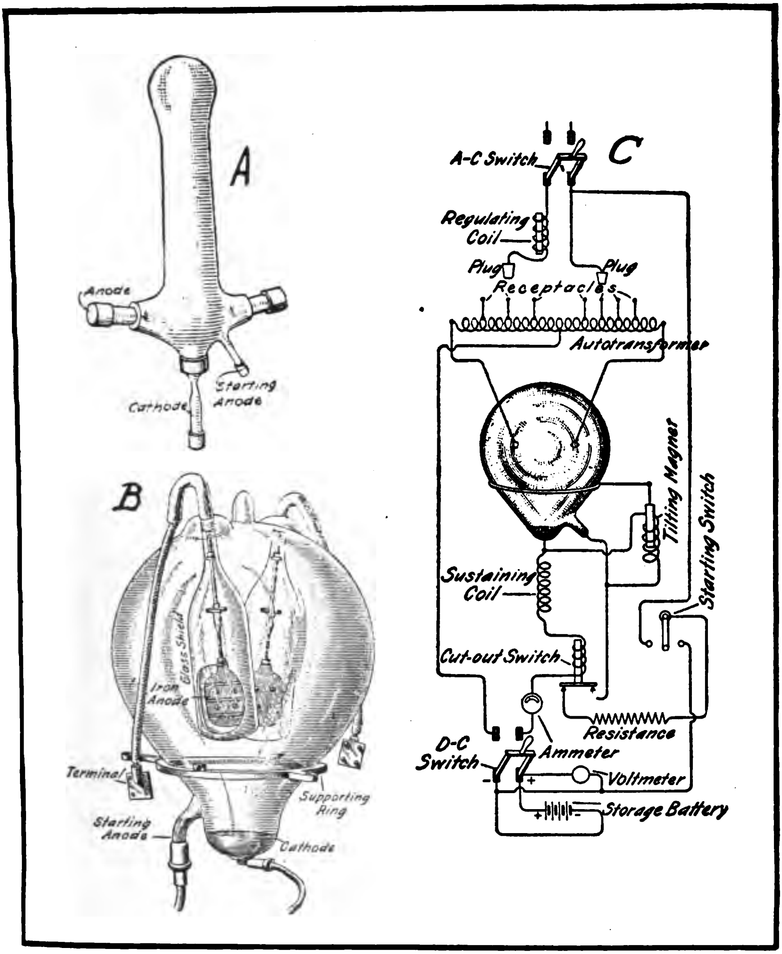


Fig. 76.—**Mercury Rectifier Bulbs and Methods of Wiring to Charge Storage Battery from Alternating Current Main.**

not provided to maintain a flow continuously toward the negative electrode. In the General Electric rectifier tube there are two anodes and one cathode. Each of the former is connected to a separate side of the alternating current supply and also through reactances to one side of the load and the cathode to the other.

As the current alternates, first one anode and then the other becomes positive and there is a continuous flow toward the mercury cathode thence through the load (in this case the battery to be charged) and back to the opposite side of the supply through a reactance. At each reversal the latter discharges, thus maintaining

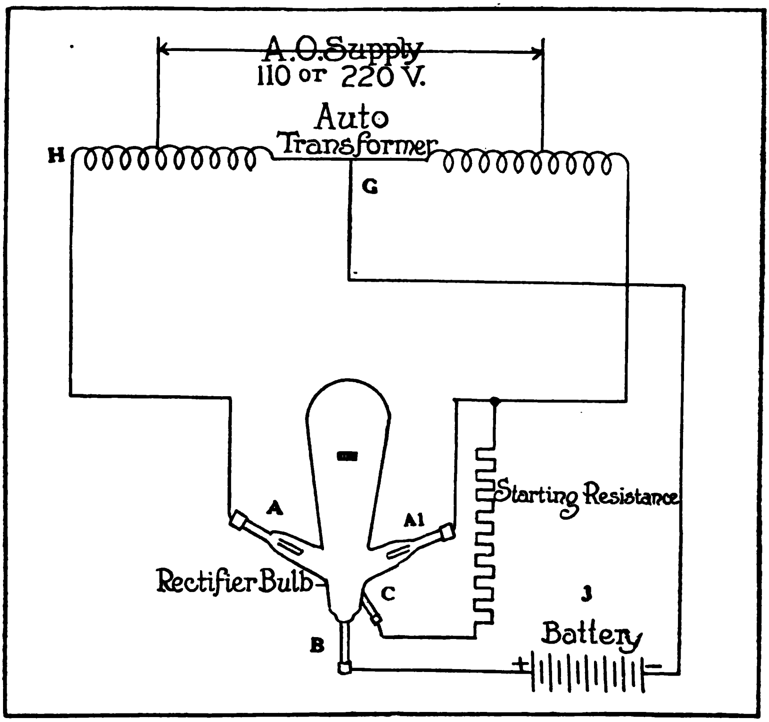


Fig. 77.—Simplified Wiring Diagram, Showing Method of Using Rectifier Bulb.

the arc until the voltage reaches the value required to maintain the current against the counter E. M. F. and also reducing the fluctuations in the direct current. In this way, a true continuous flow is obtained with very small loss in transformation.

A small electrode connected to one side of the alternating circuit is used for starting the arc. A slight tilting of the tube makes

a mercury bridge between the terminal and draws an arc as soon as the tube is turned to a vertical position. The ordinary form used for vehicle batteries has a maximum current capacity of 30 amperes for charging the lead plate type and a larger form intended for use with Edison batteries yields up to a limit of 50 amperes. Those for charging ignition batteries will pass 5 amperes for one to charge six cells and a larger one that will pass 10 amperes for from three to ten batteries. As is true of the electrolytic rectifier complete instructions are furnished by the manufacturer for their use.

The Wagner device, which is shown at Fig. 74, A, operates on a new principle and comprises a small two coil transformer to reduce the line voltage to a low figure; the rectifier proper which consists of a vibrating armature in connection with an electro magnet and a resistance to limit the flow of the charging current. A meter is included as an integral part of the set for measuring the current flow. All sets are sold for use with ignition or lighting batteries of low voltage with a lamp socket plug and attaching cord, the idea being to utilize an ordinary lighting circuit of 110 volts A. C. The magnet and vibrating armature accomplish the rectification of the current with little loss, the action after connection to the battery which is to be charged proceeding automatically. By a simple device, the current stoppage throws the main contacts open so the partially charged battery cannot be rapidly discharged. While the rectifiers are constructed to use 60 cycle, 110 volt alternating current they will work at all frequencies from 57 to 63. The size made will pass three to five amperes, the voltage being sufficient to recharge a three cell battery.

When batteries are to be charged from a direct current it is possible to use a rheostat to regulate the voltage at the terminals. The construction of a rheostat is very simple as it consists only of a group of high resistance coils of wire mounted in insulating material and having suitable connections with segments on the base plate upon which is mounted the operating arm that makes the contact. According to the manner in which these are made and wired a large resistance is introduced at first. gradually decreasing as the lever is moved over or it may operate in the re-

verse fashion, a large amount of current being allowed to pass at the first contact and less as the handle progresses across the path. Rheostats should only be purchased after consulting a capable electrician as the required resistance must be figured out from the voltage of the circuit to be used, the maximum battery

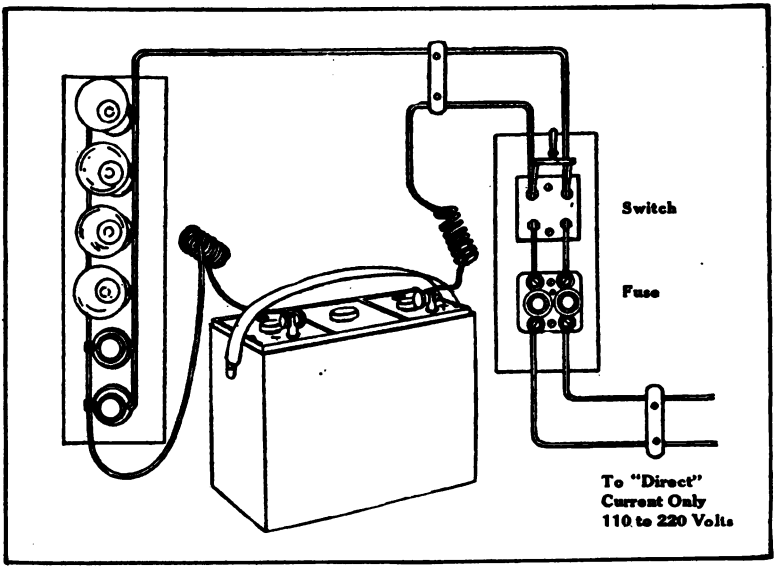


Fig. 78.—How to Charge Storage Battery by Direct Current Through Simple Lamp Bank Resistance.

current, the charging rate in amperes and the number of cells to be charged at one time.

By far the simplest method of charging storage batteries is by interposing a lamp bank resistance instead of the rheostat. These are easily made by any garage mechanic and are very satisfactory for charging ignition or lighting batteries. Standard carbon lamps of the voltage of the circuit shown should be used and the amperes needed for charging can be controlled by varying the candle power and the number of lamps used. If the lamps are to operate on 110 volt circuit, a 16 candle power carbon filament

lamp will permit one-half ampere to pass; a 32 candle power will allow 1 ampere to pass. If it is desired, therefore, to pass three amperes through the battery, one could use 3-32 candle power lamps, or 6-16 candle power lamps. If the lamps are to burn on 220 volts it should be remembered that when the voltage is doubled the amperage is cut in half, therefore the 32 candle power, 220 volt carbon filament bulbs will only pass half an ampere. The method of wiring is very simple as may be readily ascertained by referring to Fig. 78. The line wires are attached to a fuse block and then to a double knife switch. The switch and fuse block are usually mounted on a panel of insulating material such as slate or marble. One of the wires, the positive of the circuit, runs from the switch directly to the positive terminal of the storage battery. The negative wire from the switch passes to the lamp bank resistance. The lamps are placed in parallel connection with respect to each other but in series connection in respect to the battery. When coupled in this manner the current must overcome the combined resistance of the storage battery which is very low and that of the lamps. This prevents the battery being charged with current of too high voltage.

A complete commercial installation which has been used successfully with a direct current of 110 volts pressure and which has a capacity for charging 30-6 volt batteries simultaneously is composed of two charging sets either of which may be employed independently or both may be used at the same time. The method of wiring is clearly shown at Fig. 79. In this a three wire system is employed for lighting. This consists of one positive wire and two negative conductors, forming in reality two separate circuits so that one half of the installation is on one wire, while the remainder is on the other two. An upper branch is used merely for illumination. On either half of the three wire double circuit is placed a bank of lamps, these being in series with the batteries but the lamps are in multiple with each other. The board at the left has 9 sockets, that at the right 12 sockets. The number of lamps placed in these and their candle power regulate the amount of current in amperes that will pass through the battery. As we have seen, battery manufacturers advise that certain minimum and

maximum charging rates be used. Assuming that the maximum is 3 amperes, to pass a current of this value through the battery, it will be necessary to screw in 6-16 candle power lamps which will average 55 watts each, which means that at a pressure of 110 volts they require a current strength of half ampere. If fitted with 16 candle power lamps the 12 socket lamp bank will pass 6 amperes, and double this amount with lamps of twice the candle power.

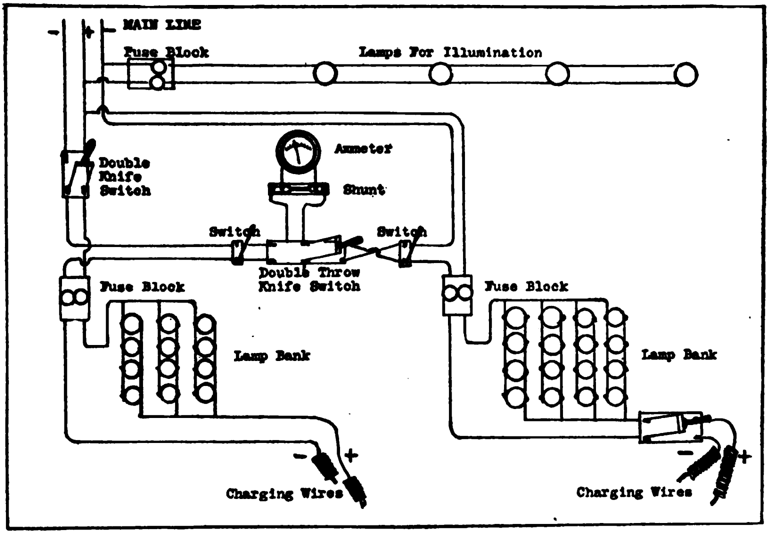


Fig. 79.—Lamp Bank Resistance for Charging a Number of Storage Batteries Simultaneously.

The meter installation shown between the charging boards is to determine the amount of current passing through the storage battery and as it is a low reading instrument, a low resistance shunt is interposed so that any overload will pass over the shunt instead of through the instrument which is calibrated to measure currents up to 30 amperes. With the small single blade knife switches in circuit the current will not pass through the instrument, as it is not advisable to include this in the circuit permanently, because the passage of current through the windings may result in injurious heating. To get a reading from either side the single blade

switch is thrown off and the double throw male member of switch is placed in contact between the blades on the side of which a reading is to be taken. It will be seen that the wires are crossed at the right of the two-way switch to cause the current to flow through the instrument in the right direction and also to have the negative terminal of each charging board at the left. This eliminates any confusion and the terminals are plainly marked so it is not possible to make a mistake when coupling batteries. When more than one battery or set of cells is being charged they are wired in series, the negative terminal of one battery being coupled to the positive terminal of the neighboring one. In connecting a battery to the charging board the negative wire should always be coupled to the negative terminal of the battery and the positive wire to the corresponding battery terminal.

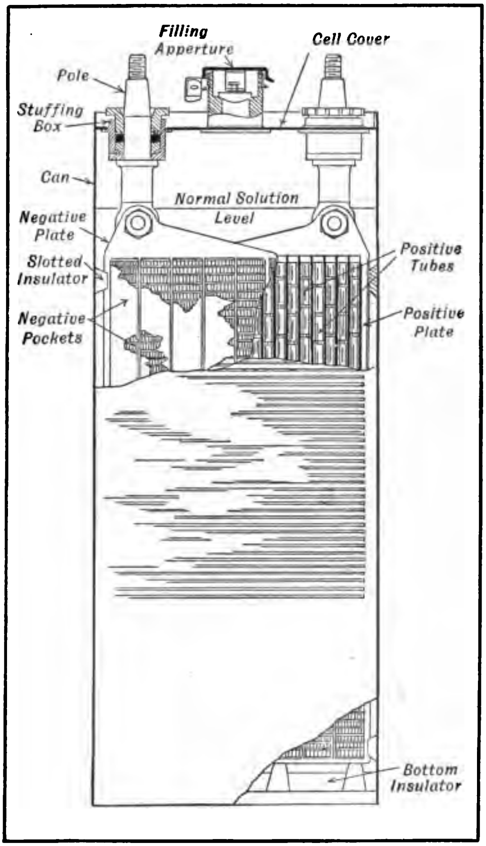


Fig. 80.—Sectional View of Edison Alkaline Storage Battery Cell.

Features of the Edison Cell.—The instructions given apply only to batteries of the lead plate type and not to the Edison bat-

tery, which is entirely different in construction. The Edison cell, shown in section at Fig. 80, uses an electrolyte consisting of 21% solution of potash in distilled water so that the electrolyte is alkaline instead of acidulous. The positive plates consist of a series of perforated steel tubes which are heavily nickel-plated and which are filled with alternate layers of nickel hydroxide and pure metallic nickel in very thin plates. The tube is drawn from a perforated ribbon of steel, nickel-plated and has a spiral lapped seam. After being filled with active material it is reënforced with eight steel bands which prevent the tube expanding away from and breaking contact with its contents. The negative plate consists of a grid of cold rolled steel, also heavily nickel-plated, holding a number of rectangular pockets filled with powdered iron oxide. These pockets are also made up of finely perforated steel, nickel-plated. After the pockets are filled they are inserted in the grid and subjected to considerable pressure between dies which corrugate the surfaces of the pockets and forces them into positive contact with the grids. These elements are housed in a jar or container made from cold rolled steel which is thoroughly welded at the seams and heavily nickel-plated. The plates are assembled in positive and negative groups by means of threaded steel rods passing through holes in one corner of the plates and insulating washers. The terminal post is secured to the middle of the rod. The complete element or plate assembly stands on hard rubber bridges on the bottom of the can as at Fig. 81 and is kept out of contact with the sides of the container by hard rubber spacers attached to the end. The can cover is also of sheet steel and contains fittings through which the electrodes pass, these being insulated from the cover by bushings of insulating material. A combined filling aperture and vent plug is secured to the center of the cover plate. For 6 volt ignition and lighting service it is necessary to use 5 cells owing to the lesser voltage of the Edison batteries. The average voltage during discharge is but 1.2 volts per cell and is not as constant as is the case with a lead battery, the voltage of which may be as high as 2.5 volts per cell.

An Edison 6.5 volt battery (Fig. 81) used for lighting or ignition may be charged completely in ten hours. A feature of the

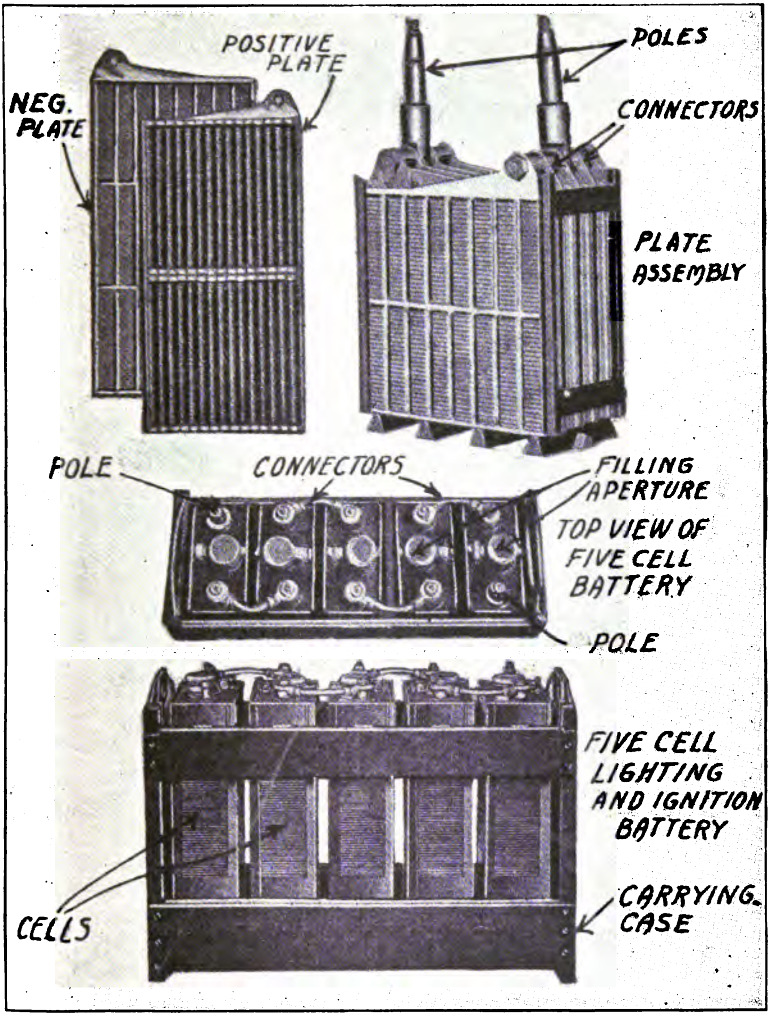


Fig. 81.—Plate Construction of Edison Cell and Method of Grouping Cells to Form Lighting or Ignition Battery.

Edison battery is that overcharging at the normal rate has no harmful effects and it is advised by the maker to give the battery a 12 hour charge once every 60 days or when the electrolyte is replenished. The electrolyte must be kept sufficiently high so as to cover the plates and any loss by evaporation must be compensated for by the addition of distilled water. Another feature in which the Edison battery is superior to the lead plate type is that the plates will not be injured if the cells are allowed to stand in a discharged condition. The external portions of the cells must be kept clean and dry because the container or can is made of a conducting material. The vent caps must be kept closed except when replacing electrolyte or bringing the level up to the proper height by adding distilled water. Care should be taken to avoid short circuiting of the battery by tools or metal objects and special emphasis is laid on the precaution that no acid or electrolyte containing acid be poured into the cells. It is said that the Edison battery has a longer life than the lead plate type of equal capacity. While eminently suited for ignition and lighting, also for vehicle work, it is not as well adapted for starting purposes as the lead plate battery is.

Winter Care of Storage Batteries.—It would not do simply to leave the battery in the car for a period of, say, 4 or 5 months without giving it any care or attention, for in that case at the end of that time it would be found to have its plates so thickly covered with lead sulphate as to make it practically useless. For storage batteries "to rest is to rust" and become ruined, unless special precautions are taken. Automobile storage batteries are all or nearly all of the sealed-in type from which the elements cannot be removed without a great deal of trouble. Therefore, the only method of keeping the plates intact consists in charging the battery at intervals of about two weeks. The following advice concerning the care of batteries during a protracted period of idleness of the car is due to the Willard Storage Battery Co., and refers especially to the batteries of starting and lighting systems.

At intervals of 2 weeks the engine should be run until the electrolyte shows a specific gravity of 1.280. If this is done regu-

larly the engine need be run only about an hour each time. But if the owner should not be in possession of an hydrometer, it is better to run the engine for 2 or 3 hours each time, for the sake of safety. To charge the battery properly the engine should be run at a speed corresponding to a car speed of about 20 mph on the direct drive. There may be cases, however, where the owner is compelled to store his car in a space where it is practically impossible to run the engine. Where this is the case, it is recommended, if electric current is available, that the owner purchase a rectifier or small charging machine. A charge over night, or for about 12 hours, every 2 weeks with this apparatus will be sufficient to keep the battery in a healthy condition. Before beginning the charging the battery should be inspected to see if it is filled with solution. If the solution needs replenishing, distilled water should be added until the solution fully covers the plates, which may be determined by removing the vent plugs and looking down into the cells. In case it is impossible to run the engine for charging and the owner does not care to incur the expense of purchasing a rectifier, he should remove the battery from the car and arrange for its storage at a garage which has charging facilities, stipulating that it must be charged every 2 weeks. The cost of having it so cared for will be nominal and will prove excellent insurance against deterioration.

To care for storage batteries of a type that is easily taken apart the following method is recommended: First charge the battery until every cell is in a state of complete charge. If there should be any short circuited cells they should be put into condition before the charge is commenced, so that they will receive the full benefit of the charge. Then remove the elements from the jars, separating the positive from the negative groups, and place in water for about 1 hour to dissolve out any electrolyte adhering to the plates. Then withdraw the groups and allow them to drain and dry. The positives when dry are ready to be put away. If the negatives in drying become hot enough to steam, they should be rinsed or sprinkled again with clean water and then allowed to dry thoroughly. When dry, the negatives should be replaced in the electrolyte (of from 1.275 to 1.300 specific gravity), care

being taken to immerse them completely and allow them to soak for 3 or 4 hours. Two groups may be placed in a jar and the jar filled with electrolyte. After rinsing and drying the plates are ready to be put away.

The rubber separators should be rinsed in water. Wood separators after having been in service, will not stand much handling and had better be thrown away. If it is thought worth while to keep them they must be immersed in water or weak electrolyte, and in reassembling the electrolyte must be put into the cells immediately, as wet wood separators must not stand exposed to the air for any unnecessary moment, especially when in contact with plates. Storage batteries always should be stored in a dry place, preferably in one where the temperature will never fall below 40° Fahr. Storage battery solution or electrolyte varies greatly in density between the points of complete charge and complete discharge. When completely discharged the electrolyte of the average battery has a specific gravity of 1.14, and a sulphuric acid solution of 1.14 specific gravity has a freezing point of about 10° Fahr. Therefore, if a completely discharged battery is allowed to stand where it is exposed to extremely low temperature it is quite possible for the electrolyte to freeze and the cells to be injured in consequence. However, as already pointed out, a battery for other reasons must not be allowed to stand in the discharged condition for any length of time. With increasirg charge the density of the electrolyte increases until, when the charge is complete, it attains 1.28 specific gravity. The freezing temperature of the solution drops very quickly as the specific gravity increases, somewhat as follows:

Spec. Grav.	Freez. Point Degrees
1.14	+10
1.16	+ 5
1.175	— 4
1.20	—16
1.225	—36
1.25	—60
1.28	—85

Consequently there is no possibility of a storage battery being injured by freezing in this latitude if it is kept in a fair state of charge.

Spark Plug Faults.—The part of the ignition system that is apt to give the most trouble, and for the most part through no fault of its own, is the spark plug which is placed in the combustion chamber in order to permit a spark to take place between the electrodes whenever it is necessary to explode a charge of gas.

Spark plug troubles are not hard to locate, as they may be readily determined on inspection. If an engine misses fire, i.e., runs irregularly, it is necessary to locate the spark plug at fault in order to remove it for inspection or cleaning. The common method of doing this is to short circuit the spark plug terminal with some metallic portion of the engine by using a wood handle screw driver, as shown at Fig. 82, A. Each plug is tried in turn, and when a good one is short circuited the engine will run even slower than before. If a plug is short circuited and the engine does not run any slower or work differently, one may assume that the plug is defective or that the cylinder is not firing for some other reason. A very simple spark plug tester which can be made by any repairman for use on cars employing magneto ignition or high-tension battery-distributor ignition, is shown at Fig. 82, B. This consists of two strips of brass riveted together at one end and fitted into a fiber or hard rubber handle. The brass strips are spread apart so that contact may be made between the plug body and insulated central terminal of practically any size plug. When a four-cylinder or six-cylinder engine uses individual spark coils for ignition, it is possible to detect the missing cylinder by holding down the coil vibrators with the fingers, leaving the engine to run on one of the coil units or one cylinder as the others are cut out. Each coil unit is tried in turn, and when all others are rendered inoperative except the defective one or the coil leading to the defective spark plug, the engine will stop. The wire leading from the spark coil is traced to the spark plug, and that member removed for examination. The common trouble is a deposit of burnt oil or carbon around the insulator and between the plug points. This short circuits the current as it provides an easier path for

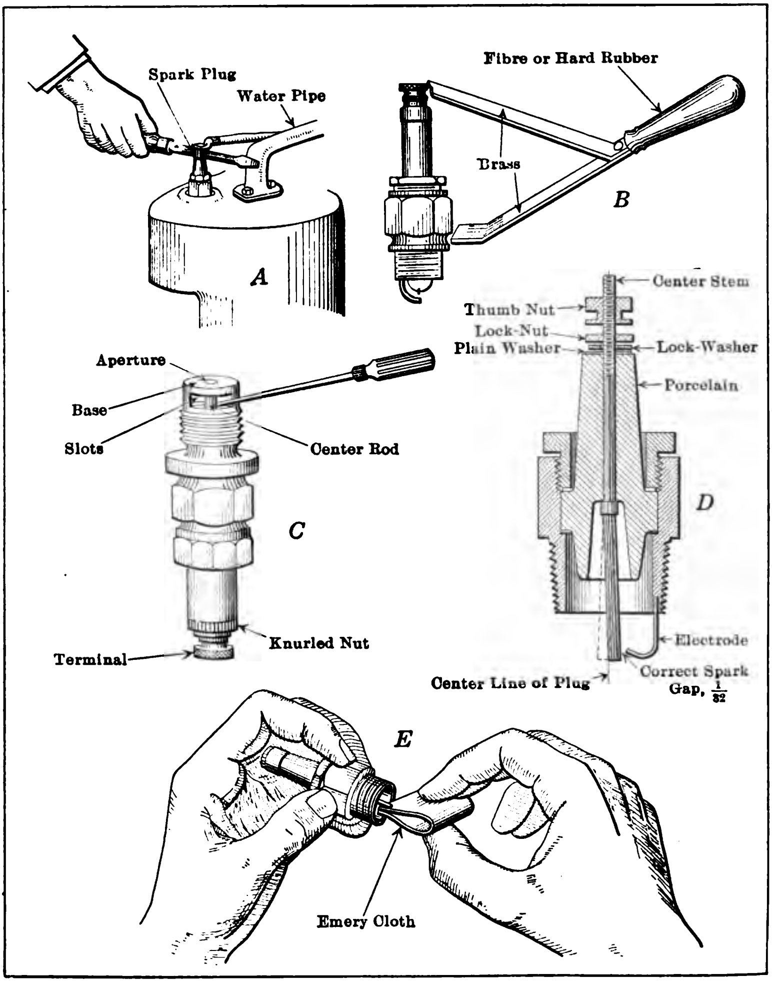


Fig. 82.—Showing Methods of Testing Spark Plug and Adjusting Air Gap Between the Electrodes.

the passage of electricity than the air gap does. If the points are too close together the plug will become short circuited very quickly and ignition is apt to be erratic because the spark does

not have sufficient heat to ignite the mixture. If the spark points are too far apart the resistance is apt to be too great for the current to jump the air gap. The porcelain may crack or become broken, in which case the current is apt to short circuit if the break is down in the plug body. If a mica or lava insulator becomes oil soaked, this also will produce short circuit.

Most plugs are of the easily separable form, as shown at Fig. 82, A, in which case the insulator may be easily removed by unscrewing the packing nuts that keep it seated against the plug body. If the plug is clean when examined the thing to do is to see that the spark gap is correct. This should be about one-thirty-second inch. Whenever a spark plug is to be put into use, whether it is a new one or old one which has been cleaned, the spark points should always be set so there is a gap of about the thickness of a smooth ten-cent piece between them. The method of obtaining a correct spark gap depends entirely upon the type of the plug. In the plug shown at Fig. 82, C, which has a plate at the end, it is necessary to bend over the center stem by using a small screw driver or similar tool as indicated. With a plug of the form shown at D the center stem is bent the proper distance away from the small hook-shaped wire or electrode which projects from the bottom of the spark plug body. In some plugs it is easier to bend the central stem than the side electrode, as the latter is of hard material, whereas in others it is not possible to bend the central electrode and the point attached to the plug body must be bent instead. It is important when replacing the porcelain insulator after cleaning to make sure that the packing nut is drawn down quite tight in order that the joint will be tight enough to hold the explosion pressure. It is also necessary to screw down the small hexagon lock nut on top of the spark plug porcelain, as if this is left loose the center stem of the plug will be free to turn in the porcelain, especially if the thumb nut or terminal is being tightened. It will be apparent that if the center stem is bent over toward the side electrode in the manner shown at D, that if it is turned a very small part of a circle the size of the gap between the center stem and side electrode will be altered appreciably. If the porcelain is found covered with oil and car-

bon when removed, it should be thoroughly cleaned, care being taken not to scratch the glazing on the porcelain surface, as if this glaze is destroyed it will be possible for the porcelain to absorb oil. The interior of the plug body and the electrodes should also be scraped clean of all carbonaceous matter. If the porcelain is scratched or defaced in any manner it should be replaced with a new one. If the plug is apparently in good condition and yet the cylinder refuses to fire, it may be well to substitute the plug with one known to be in good condition, as there may be some minute short circuit in the porcelain that is not apparent upon inspection.

Plugs using mica insulation are very deceptive, as in many cases short circuits exist that cannot be detected by the eye in daylight. A good way to test a suspected mica plug is to lay it on top of the cylinder after dark, taking care not to have the insulated terminal in contact with any metal parts except the high tension current lead. The engine is then run on the other cylinders and the inside of the spark plug watched to see if sparks jump between the insulator and the plug body, instead of between the points. If a short circuit exists it will be easily detected by the minute sparks plainly evident in the darkness. It is sometimes possible to test a plug out in daytime by shading it from the light in some manner, as with a black felt hat. After the spark points have been set correctly, it is well to double up a piece of emery cloth with the abrasive surface on the outside, as shown at Fig. 82, E, and move it back and forth between the plug points a number of times to brighten them up and to insure that there will be no foreign matter present between them that is apt to short circuit the current. An old tooth-brush and gasoline are the best tools for cleaning a spark plug without taking it entirely apart as stiff brush bristles will remove any oil or material soluble in gasoline. Acetone is a solvent for carbon, and if that material is not baked on too hard it is possible to remove the deposit without scraping it off.

Many cases of ignition trouble have been traced to the use of improper spark plugs or to faulty location of these members. Manufacturers of spark plugs have given the matter of location considerable thought during recent years, and the endeavor is to

produce a plug specially designed or adapted for the motor for which it is to be used. The spark plug shell or base is constructed so the spark points will project into the combustion chamber. It is also important to make provision for proper cooling of the spark plug. This last named factor is an important one that is seldom given consideration by owners or repairmen who change the spark plugs without making sure that they are adapted to the motor. To obtain the greatest efficiency from the explosion it is important that the spark points project into the combustion chamber in such a way that they be surrounded with cool fresh gas. If the gas of the plug is located in a recess or pocket, as indicated at Fig. 52, A, dead gas is apt to accumulate about the points, and combustion will be much slower than it would be with the spark plug located as at B. It will be evident that with this construction of the valve cap the spark points project into the induction chamber, permitting the spark to take place in fresh mixture and promote rapid spread of the ignition flame. Another faulty mounting when a plug is located directly in the combustion chamber is shown at C. It will be apparent that with a projection from the plug body having a space around it in which the hot gases may collect, the plug will heat up much quicker than the mounting shown at D in which the heat will be conducted away by the cooling water. A plug that becomes heated will tend to soot up and carbonize much quicker than one in which provisions have been made for proper cooling.

Induction Coil Faults.—The high-tension induction coil is one part of the ignition system that can seldom be repaired outside of the factory. In the first place it is not possible to reach the interior parts of an induction coil because the windings and condenser are usually imbedded in a hard insulating compound that has been poured into the coil box in a molten condition, and which becomes as hard as stone when it sets. The only part of an induction coil that is possible to correct is faulty vibrator action, and fortunately the vibrator is about the only part of a well-made coil that demands attention. If the vibrator does not buzz when the circuit is closed at the timer and the wire leading from the timer to the coil unit is found in good condition, the

trouble is due to a broken connection inside of the coil box or the contact points do not touch. If the vibrator operates as it should and there is an extremely bright spark between the points and a weakened secondary spark, it is reasonable to assume that the condenser inside of the coil box is ruptured.

If there is a proper vibration or buzz at the vibrator and no secondary spark from the high-tension terminal, the trouble is either a broken high-tension connection or a short circuited secondary winding. Sometimes a wire inside of a coil is twisted off where it fastens to the terminal screw, due to that member being turned around several revolutions with a pair of pliers. A case of this kind may be fixed by removing the bottom or top of the coil box, as the case may be, and making sure that the connection is re-soldered to the terminal post. A punctured winding or short circuited condenser can only be repaired by the coil manufacturer, and in most cases it is cheaper to procure a new coil unit, which is easily removed in modern coils, than to attempt to have the old one repaired.

When a coil unit is suspected of being defective it is easy to ascertain if this is the case by changing it for one of the coil units which is known to be in good condition. If the cylinder which was formerly served by the good coil unit now begins to skip, one may assume that the coil unit is at fault. If the trouble has not been due to other causes, the cylinder that was formerly at fault will begin to operate as it should as soon as the spark plug is connected to the good coil unit which has been substituted for the one thought to be defective.

Adjusting Coil Vibrators.—The repairman who understands the vibrating spark coil is the exception rather than the rule. Many are able to adjust a vibrator, but do not know how to locate troubles, or to remove the exposed component such as the bridge, vibrating spring, etc., and reassemble the parts correctly. If the vibrator buzzes weakly when contact is made at the timer, the first thing to do is to test the battery to make sure that there is sufficient current available to operate the vibrator, then the contact points should be examined to see that they are clean and smooth. Various defective conditions are shown at Fig. 83, A; any one

of these will interfere with correct contact and with proper vibrator action. At A-1 a pit has been burnt in the lower point and a projection has been built up on the upper one. At A-2 the points have been cleaned with a file which has been inserted at an angle so the contact members do not have a true flat surface. At A-3 a point has been built up on one side of the contact of both vibrator springs and contact screw points. As these contact points

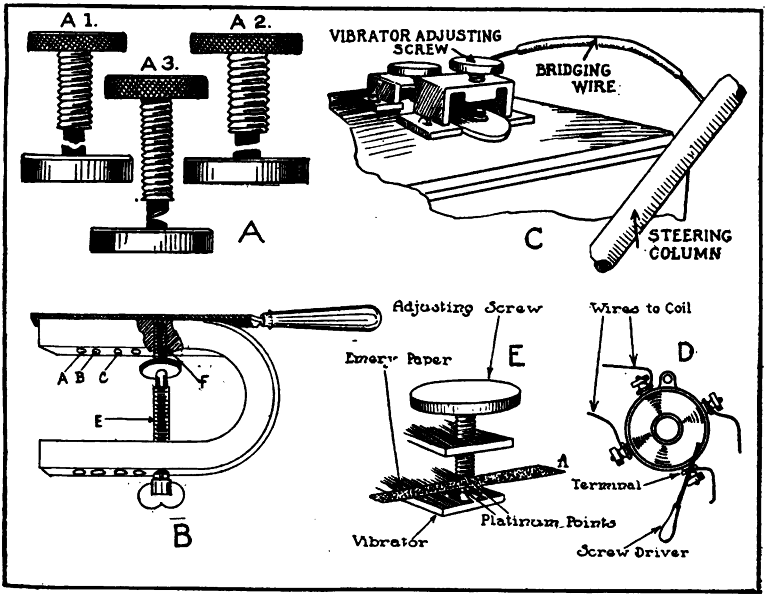


Fig. 83.—Methods of Cleaning Induction Coil Vibrator Contact Screws.

are of platinum it is important to remove as little of that valuable material (which is now worth more than gold) as possible.

For this reason it will be desirable for a repairman working on cars using vibrator coils to provide himself with the simple fixture shown at Fig. 83, B, which insures that the points will be dressed true without removing much material. The fixture is a simple U-shaped piece of hardened steel having a series of holes, A, B, C, drilled into it of such size as will permit the insertion

of the most commonly used sizes of vibrator adjusting screws. These are not threaded, the screw F being a free fit in the hole corresponding to the outside diameter of the thread. A feed screw E may be interposed under the adjusting screw in order to feed it up against the smooth file used to clean off the roughness. This screw may be shifted into any one of the tapped poles under the holes A, B and C for feeding different sized contact screws.

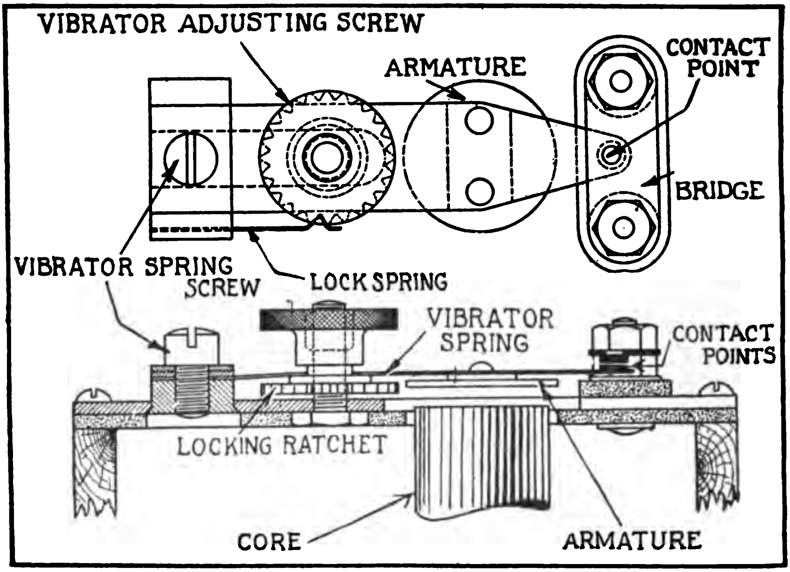


Fig. 84.—Typical Induction Coil Vibrator.

The conventional vibrator is shown at Fig. 83, C, and another form at Fig. 84. It will be noticed that this consists of a vibrator spring or armature carrying one contact point and a bridge member over it carrying another contact which is set into a knurled head adjusting screw in that at Fig. 83, C. The smaller bridge holds the vibrator spring and is also provided with a knurled screw so the vibrator spring tension may be adjusted. Directly under the vibrator is the iron core which attracts it to break the contact between the points. The farther away the vibrator is from

the core the more current will be needed to actuate the vibrator. The spring tension should be sufficient, so that the trembler will vibrate fast enough to produce a pronounced buzzing sound. If the vibrator spring lacks elasticity, too much current will be consumed which is an important item if the current for ignition is derived from a dry cell battery. In adjusting the coil vibrator it is not necessary to turn the motor over to establish contact as the tuning up may be readily performed on most coils by connecting a wire to the steering post as shown at C, and touching the knurled head of the adjusting screw or the bridge carrying it with the other end of the wire. It is necessary, of course, to have the switch on the coil in the "on" position. Another method of accomplishing this is to short circuit the timer with a screw driver as shown at B, which is used to bridge the wire terminal and the aluminum timer case. In this way each of the vibrators may be made to buzz in turn. If the points are not too badly burnt it is possible to clean them with a piece of very fine emery cloth as shown at Fig. 83, B, without removing either vibrator or contact screw from the top of the coil. Where battery current is used it is well to test the current consumption of the coil from time to time as the vibrators are adjusted. It is possible to have a coil draw twice as much as needed if the vibrator spring tension is too great. The current consumption will vary from .5 to 2.2 amperes, a fair average being about 1 ampere. The usual primary voltage needed is 5 or 6, and the trembler vibrations will vary from 100 to 400 per second. If the vibrator tends to stick, the core should be filed off as well as the undersurface of the vibrator to remove any rust that may be present between the surfaces. A projecting core wire sometimes interferes with proper vibrator action. Make sure the top of the core is smooth and bright.

Roller Contact Timer Troubles.—When a timer of the roller contact form is used, ignition is apt to be irregular should the spring attached to the free end of the roller arm break. If the interior of the device is filled with dirty oil, the current is apt to be short circuited. If the device has been oiled with a lubricant having too much body, the roller is not apt to make good contact with the metal segments and ignition will be erratic. De-

preciation in the bearing pin on which the roller rotates or of the fulcrum pin on which the roller arm swings will also result in irregular ignition. If the motor runs steadily at low speeds but misses fire at high speeds, and the trouble has been traced to the timer, it is necessary to feel around the inside of the fiber ring with the finger to see that this is smooth and perfectly round, and that the contact block faces are flush with the surface of the ring. If the blocks are worn below the surface of the ring, the roller is apt to jump the space at high speeds, due to the low block, and not establish an electrical contact. At low speeds the tension of the spring is sufficient to keep the roller bearing against the contact blocks, as it will follow the irregular contour of the timer interior without difficulty. If the segments are badly worn and the fiber ring roughened, the timer casing should be chucked in a lathe or grinding machine and the interior ground smooth and perfectly round with a small emery wheel. The writer has seen some mechanics attempt to take a light chip out of the timer interior, as they were ignorant of the fact that the contact blocks were of tool steel and hardened. A fast-running, free-cutting emery wheel is the best tool to use for smoothing down hardened steel segments. The stem or bolt attached to the contact block must pass through a fiber washer or bushing in order that it be insulated from the timer body. If these bushings crack, there may be an opportunity for leakage of current, especially on the Ford car, where the ignition current is derived from the magneto and is stronger than that usually produced by a chemical battery.

Wiring Troubles and Electrostatic Effects.—The principal troubles that are apt to occur in the wiring systems are evident on inspection, these consisting usually of a break in the conductor, which may sometimes be concealed by perfect insulation covering; wearing away of the insulation due to abrasion between the wire and some metal portion of the car which eventually results in a short circuit and the wiring becoming oil soaked and failing to properly carry the charge of current which leaks through the defective insulation. The wiring of a complete dual ignition system in which two radically different methods of ignition are used

is shown at Fig. 85. One system consists of a set of low tension igniter plates, mechanically operated from a suitable camshaft, the other method, which is independent, has high tension ignition plugs operated through a timer of the usual form. At the present time where dual ignition systems are provided the usual practice is

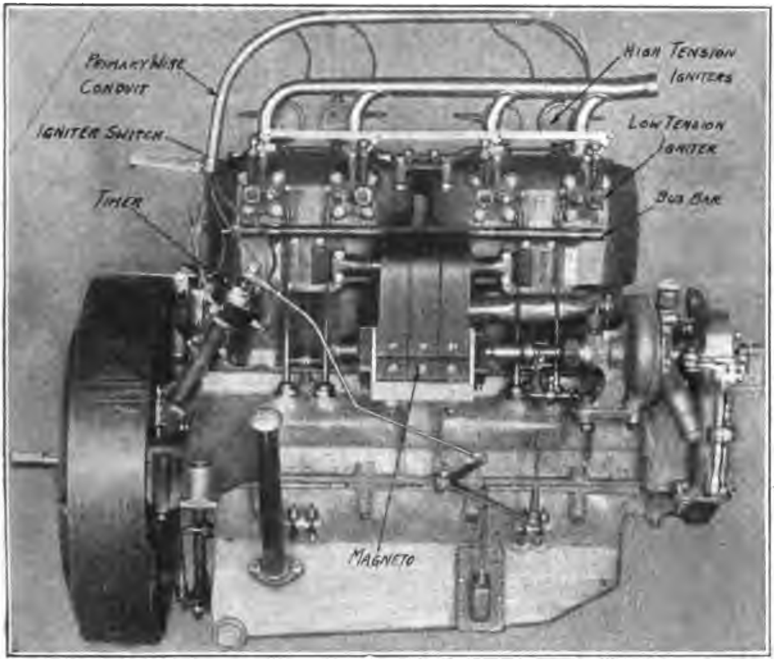


Fig. 85.—Side View of Engine Used on Some Columbia Automobiles Having the Rare Combination of Both High and Low Tension Ignition Systems.

to use two high tension systems, one of which will derive its current from a battery and coil, the other which will receive the energy of a high tension magneto. A typical double system adapted for six cylinder, engine ignition is shown at Fig. 86. In this two spark plugs are carried in each cylinder, one over the intake, the other over the exhaust valve. A battery timer is mounted close to the dash from which six primary wires go to the

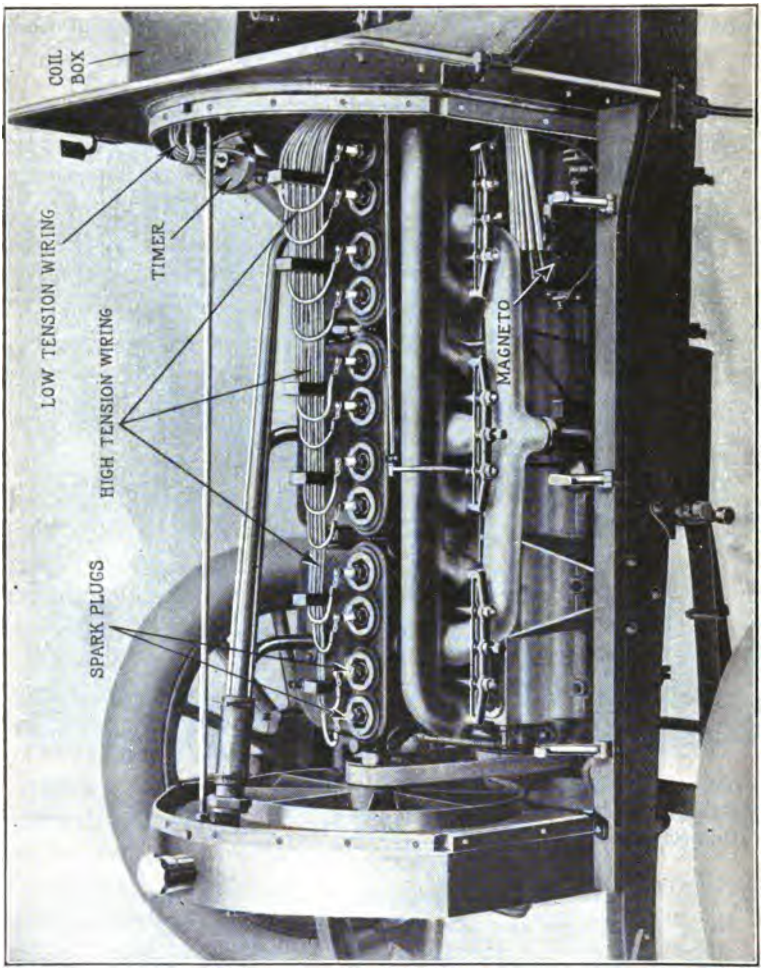


Fig. 86.—View of Stevens-Duryea Six Cylinder Power Plant Showing Arrangement of Parts of Double Ignition Systems.

individual coil units of the coil box. High tension wires come from the bottom of the coil to one set of spark plugs. Another set of high tension wires extends from the magneto distributor to the remaining set of spark plugs.

It will be apparent that in both of the systems shown that considerable care is taken to have the wiring carried in an orderly manner and kept out of contact with the metal portions of the

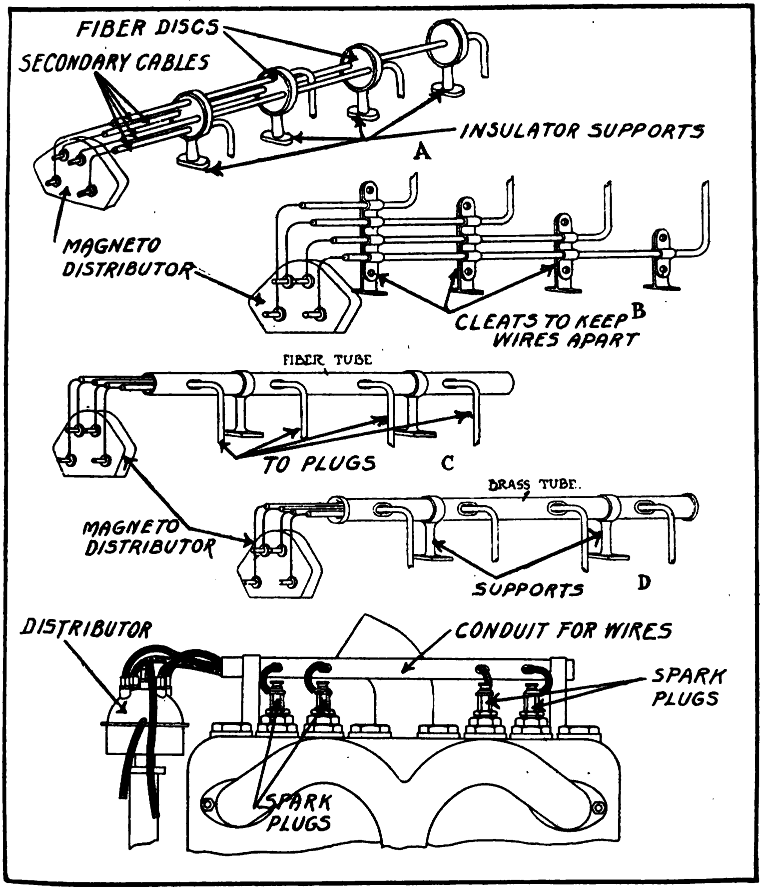


Fig. 87.—Methods of Insulating and Supporting Secondary Cable Assembly.

cylinder by suitable insulating blocks, usually made of fibre, as at Fig. 86 or Fig. 87, A, or in a fibre-lined metallic conduit, as shown at Fig. 87, D.

A typical double ignition system which has been used on some models of the Locomobile is clearly shown at Fig. 88. The method of running the wires for the primary circuit is very clearly outlined at A. The complete wiring diagram showing the high tension leads going from the magneto distributor to the spark plugs is shown at B. With a system of this kind the current may be derived from a battery which is timed by a primary circuit breaker attached to the magneto contact breaker box and sent through a single unit coil secured to the dash. The secondary current from the coil is led to the center of the magneto distributor, which serves the dual purpose of directing the high tension current from either the magneto armature or the induction coil to the spark plugs in the proper firing order. The usual method of housing the secondary cables in a conduit of insulating material so that there will be no liability of short circuiting due to oil accumulations or to contact with metal parts is so clearly shown at Fig. 87, C, that further description is unnecessary.

The repairman does not generally recognize the fact that the manner in which the high tension cables are led from a magneto or spark coil to the spark plugs is sometimes the cause of misfiring and ignition irregularities which are hard to locate. A spark may sometimes occur in a cylinder in which the piston is going down on its suction stroke which is not due to defective insulation of the wires or to short circuiting, but to an electrostatic action between one wire and a neighboring one through which no current is flowing. Endeavor should always be made to keep the secondary cables as short as possible, as in some cases if a conductor is too long the tendency is toward an unreliable spark. Some ignition experts condemn the practice of running the secondary wires close together in a fiber-lined conduit and recommend the use of fiber cleats secured to supports extending from the engine and provided with grooves that will hold the cables some distance apart.

When individual unit coils are used a condition that often puzzles those who have had no previous experience with it is what is

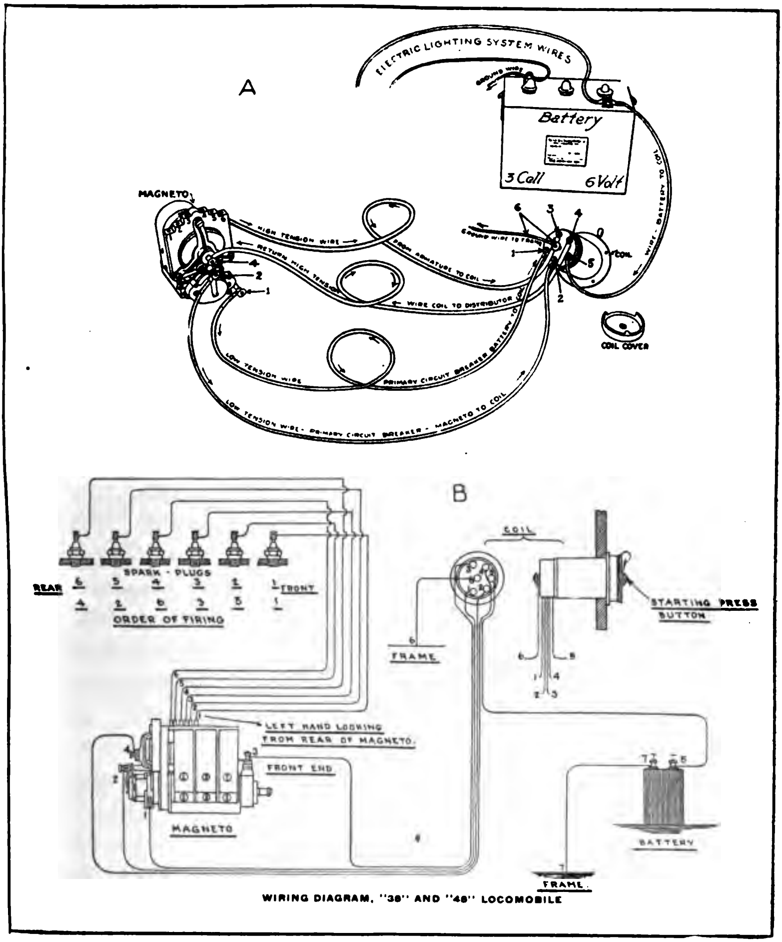


Fig. 88.—Wiring Diagram of Bosch Double Ignition System Used on Locomobiles Models 38 and 48.

known among old-time repairmen as "bucking," this usually being evidenced on engines of the four or six cylinder forms. The symptom is the same as a premature explosion in some one of the cylinders, this having a tendency to cause the engine to come to an abrupt stop. One is often led to believe that a short circuit ex-

ists at one of the timer wires which allows a contact being made at the wrong time, producing a spark in the cylinder about to fire before the gas is fully compressed or the piston has reached top center. This is due to an inductive interference between one induction coil and a neighboring one. It is known that when the primary coil becomes energized in any unit the core becomes a magnet, and as is common with all bar magnets, lines of force are given out which run from the north to the south poles and which induce a current in the secondary winding of the transformer coil. If this magnetic influence does not go astray from its proper confines no trouble will be experienced. If a portion of this magnetic field strays over into a neighboring coil unit enough voltage may be induced in the secondary winding of the latter to produce a weak spark at a spark plug connected with a coil which rightly should remain inactive. This condition is more noted with old-style induction coils than with modern ones, and usually results when the motor is running slowly. The trouble has been eliminated in many of the later forms of multiple unit coils by providing anti-induction shields between the units. These are merely metallic strips in which the energies from the stray magnetic force is dissipated in the form of eddy currents instead of cutting wire layers of adjacent units. If this trouble is experienced and none of the common faults are found to exist, such as carbon deposits and rough edges in the interior of the combustion chamber or long, thin spark plug points which remain incandescent and retain heat from a previous explosion, one may suspect trouble in the multiple unit coil. It has been cured at times by inserting thin strips of sheet

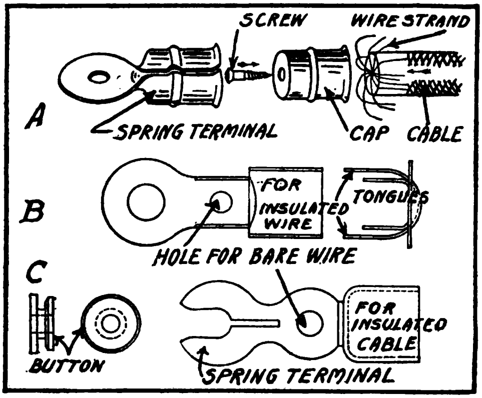


Fig. 89.—Forms of Terminals for Attachment to Ignition System Cables.

iron between the coil units. The most frequent cause of "bucking" is defective insulation of the secondary wires, which allows the current to jump from one cable to another. This is sometimes found to be the case when all cables are passed closely together

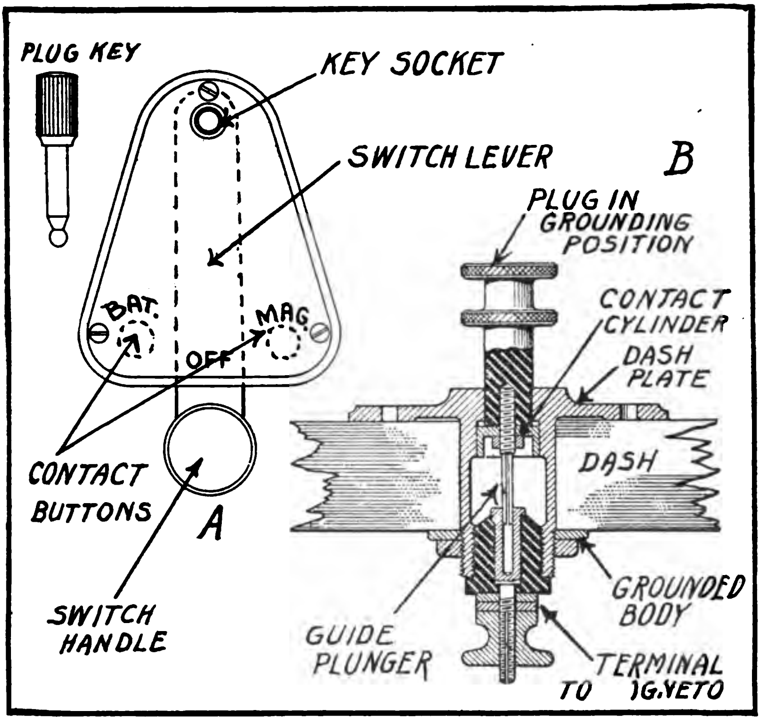


Fig. 90.—Construction of Ignition Current Switches Outlined. A—Lever Type Magneto and Battery Switch. B—Plug Switch for Controlling One Circuit.

through a common tubular conduit, and is not apt to result when wires are carried apart in cleats, as in Fig. 87, B.

Battery Ignition System Hints.—See that the wires are heavy enough to carry the current and that all the connections are kept clean and bright as every corroded joint causes needless resistance.

Inspect battery connections etc., occasionally as they have a habit of working loose.

Look well to the ground connection, which should be very securely made and placed where it will not corrode.

Be sure the battery, especially if dry cells are used, is where it cannot get wet, as the paste-board may absorb sufficient moisture to short circuit the cells.

See that all wires are securely fastened so that they cannot by any means rub or chafe against either wood or metal parts· especially the secondary wires.

Frequently examine the condition of the plugs, as troubles caused by plugs are often looked for elsewhere.

Don't allow the wires to become water- or oil-soaked, as short circuiting will probably result.

Don't screw down electrical connections with the fingers, as a tight joint cannot be made. Use pliers.

Don't allow the storage battery to get so far discharged that it will not operate the coil. See that the vibrators are set as lightly as possible to run the engine without skipping, otherwise they will waste current.

Don't take it for granted you have ignition trouble every time the engine stops.

Don't start out knowing the battery to be nearly exhausted, as it may run all right to start with, but will probably go out of business at a most inopportune time and place.

Don't adjust the coil vibrator for the biggest possible spark, as it wastes current.

Don't think a multiple unit coil is no good if the vibrators do not buzz exactly alike.

Don't test storage batteries with an ammeter unless they are charging or discharging.

Don't strain the coil by disconnecting the secondary wires completely so that no spark can jump, or by testing how far it will jump.

Don't screw or nail anything on to the coil box, as you may injure it.

Don't tolerate any loose wires or poorly made connections. Fix

them at once, using terminals for all wires as shown at Fig. 89, making sure no loose strands of wire project. Terminals should be securely soldered to wire.

Be sure all timer contacts are clean, contact points properly adjusted and distributor brushes O. K. Carbon dust in distributor will cause skipping as well oil in timer portion on points.

Don't think the ignition system will function properly with loose or dirty switch connections. Examine switch parts as shown at Fig. 90 for looseness or corrosion of contacts.

Timing Battery Ignition Systems.—In timing a motor using a battery ignition system with individual vibrator coils to supply the current to respective cylinders, the first thing to ascertain is the firing order of the engine to be timed. The diagram, Fig. 91, shows all components of a battery ignition system, also a sectional view of one of the cylinders of the engine, showing the position of the piston when the spark should occur in the cylinder with the primary timer fully advanced. When the primary timer is fully retarded the spark will take place after the piston has reached the top of its stroke and has started to go down on the explosion stroke. The four unit spark coil has a two point switch on its face and has ten terminals. Four of these which are protected by heavy insulators or bushings of hard rubber run to the spark plugs as indicated. These are the secondary terminals. The two primary terminals under the switch are connected to the positive poles of the dry cell and storage batteries respectively, the negative terminals of the two batteries being joined together by a common wire and grounded. This leaves four primary leads which go to insulated terminals connecting with the segments of the timer.

The method of timing an engine is very simple. The spark advance lever on the steering wheel is advanced fully. The inlet valve of cylinder No. 1 is watched as the engine is turned by the hand crank. Just after the inlet valve closes which indicates that the piston has started to go up on its compression stroke the piston travel may be gauged accurately as it moves up by the timing rod inserted through a petcock in the top of the cylinder or through a valve cap opening. If the engine is not provided with a relief

cock or spark plug that will permit the use of the gauge rod, the flywheel markings may be utilized to determine the center corresponding to the end of the piston upward movement. The vibrator of coil connected to cylinder No. 1 should begin to buzz with the

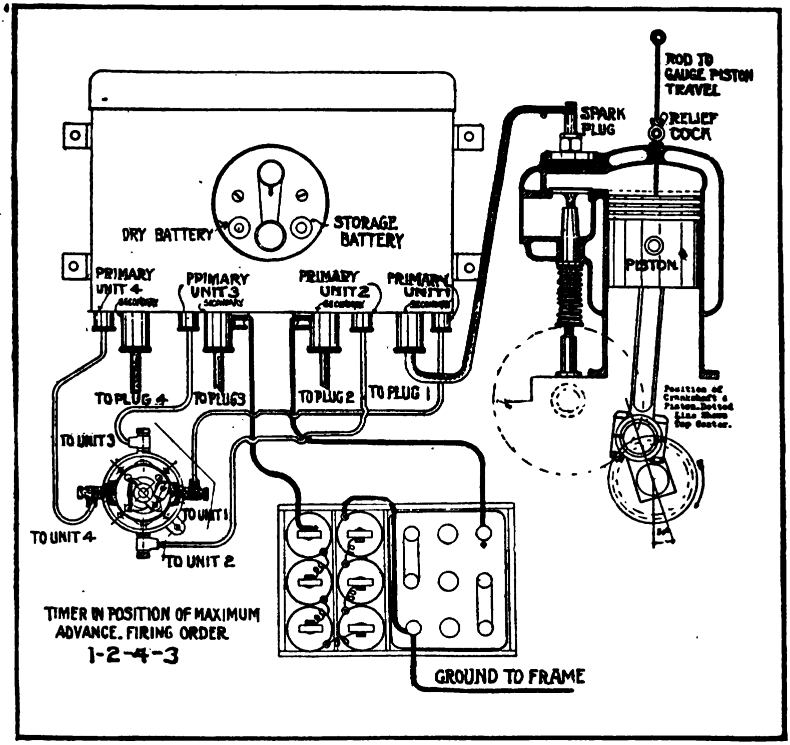


Fig. 91.—Simplified Wiring Diagram Explaining Methods of Timing Spark in Battery Ignition Systems.

timer casing in full advanced position before the piston reaches the end of its upward stroke. The amount of crankshaft travel is about 30 degrees from the point where the spark takes place to that where the piston reaches the top of its stroke. If the timer casing is set in full retard position the spark should take place 30 degrees of the crankshaft travel after the piston has left the

end of its compression stroke. Some engines have the spark set 45 degrees advance. With the spark advance lever set about half way of its travel the spark may be made to occur just when the piston reaches the end of its compression stroke, or on top center. It is necessary to provide a wider range of spark advance on a battery and coil ignition system than when a magneto is used, as it is said that a range of advance of 60 degrees is sufficient for four-cylinder motors and 27 degrees for six-cylinder motors with magneto ignition.

In timing a strange car it is easy to tell whether the movement of the spark lever advances or retards the timer case by noting the direction of movement of that member. If the spark advance lever is pushed in a certain direction, say from the point on the sector nearest the driver to the other extreme, and the segments on the timer move to meet the advancing contact roller, it is evident that a movement of the spark advance lever from front to rear advances the ignition. If the timer case oscillates so the segment moves away from the advancing contact roller, that movement of the spark lever retards the ignition. In most timers the rotating contact member is fastened to the shaft in such a way that it may be moved independent of engine rotation, if desired, by releasing the fastening. Sometimes it is held on a tapered shaft by a clamping nut, in other constructions it is driven by a hollow shaft which is set screwed to the timer driving shaft the position of which can be changed as desired. In every case the roller should be set in contact with the segments joined to coil unit No. 1, the remaining terminals being wired according to the firing order and the direction of rotation of the timer brush. In the diagram now under discussion after the roller leaves unit No. 1 segment it will go to that in connection with unit No. 2, then to the one joined to unit No. 4, and finally to the terminal conveying the electrical current to unit No. 3. This means that the plug in cylinder No. 1 fires first, followed by those in cylinders 2, 4, 3, in the order named. With the switch lever in the position shown or between the two contact buttons, the ignition is interrupted and battery current cannot flow to the coil unit. If the switch lever is moved to the button on the right marked "storage bat-

tery," the secondary current producer will furnish ignition. If moved to the button on the left, the dry cells will be brought into action. The same method is employed in timing a two, three or six-cylinder motor, the only precaution to be observed being to run the wires from the timer to the coils so the cylinders will fire in proper order.

At one time secondary distributor systems using a single unit vibrator coil for firing a multiple cylinder engine were very popular, but at the present time few cars use the long contact timer and distributor combination. The modern cars that employ battery ignition use a short contact timer and a non-vibrator coil unit. Popular systems of this nature are the Atwater-Kent and the Delco, both of which have been previously described. Practically the same method of timing is employed with these systems except that there is but one primary terminal on the contact breaker portion of the distributor which is joined to the corresponding terminal of the spark coil. A proper distribution of current to the cylinders is made by connecting the distributing terminals to the plugs in proper firing order.

CHAPTER III

MAGNETO IGNITION SYSTEMS

Magneto Generator Construction—Low Tension Magnetos—Typical American Magneto Forms—Magnetos for Eight- and Twelve-Cylinder Motors—Simple Magneto Ignition System—Double System—Transformer Coil Method—Dual Ignition—Duplex Ignition—Two-Spark Magneto—Magnetic Plug System—Impulse Starter—Automatic Spark Advance—Low Tension Magneto Troubles—High Tension Magneto Troubles—Recharging Magnets—Adjusting Parts—Application to Typical Engines—Timing Magneto Ignition System—Firing Orders of Typical Engines.

Magneto Generator Construction.—The magneto is a simple form of dynamo and a mechanical generator of electricity in which permanent magnets are used to produce the magnetic field and between which the armature revolves. The permanent magnets are called "field magnets" and at their ends are provided cast-iron shoes which form the walls of the armature tunnel and which are known as pole pieces. A typical magneto adapted for single-cylinder ignition is shown in section at Fig. 92. It consists of two compound horseshoe magnets attached to the pole pieces which collect and concentrate the magnetism upon the armature. The armature is shuttle-shaped and carries a double winding of wire which consists of two coils, one of coarse, the other of fine conductor. The armature is attached to end pieces which carry shafts and the whole assembly revolves on annular ball bearings. An ebonite or hard rubber spool is carried at one end while the condenser is housed at the other. The make-and-break mechanism is partly carried by an oscillating casing and the revolving member is turned from the armature shaft.

The current generated in the coil is delivered to a metal ring on the ebonite spool from which it is taken by a carbon brush and delivered directly to the spark plug. Every time the contact points

in the make-and-break devices become separated, a current of high potential passes through the wires attached to the spark plug and produces a spark between the points. The magneto is the simplest and most practical form of ignition appliance as it is self-contained and includes the current generator and the timing device in one unit. In the one-cylinder form shown all connections are made inside of the device and but one wire leading to the spark plug is necessary to form the external circuit.

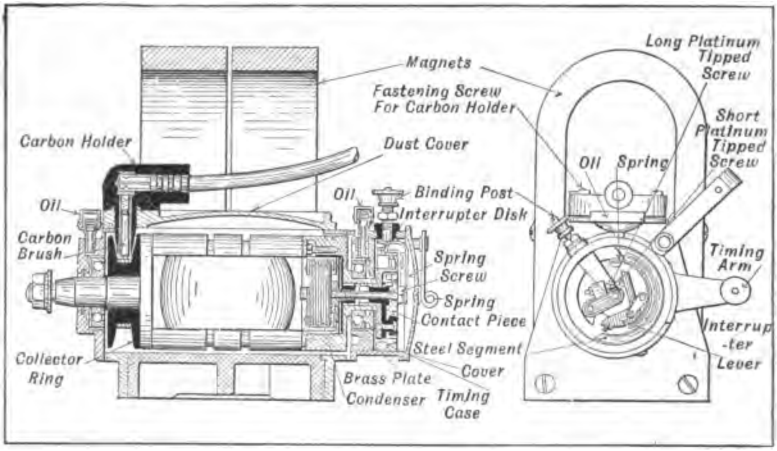


Fig. 92.—Simple High Tension Magneto for One Cylinder Ignition, a Complete Apparatus Comprising Source of Current and Timing Device as Well.

A magneto employed for multiple-cylinder ignition is not much more complicated than that used for single-cylinder service, the only difference being that a different form of cam is provided in the breaker box and that a secondary distributor is added to commutate the current to the plugs in the various cylinders. The distributor consists of a block of insulating material fixed to the magnets which carries as many segments as there are cylinders to be fired. A central distributing arm or segment is driven from the armature shaft by means of gearing, and is employed to distribute the high-tension current to the spark plugs. The spacing

of the distributor segments does not differ materially from that of the battery timers previously described.

Various distributor forms used on magnetos are shown at Fig. 93. That at A is employed for a double opposed cylinder motor and the contacts are separated by a space of 180 degrees. When

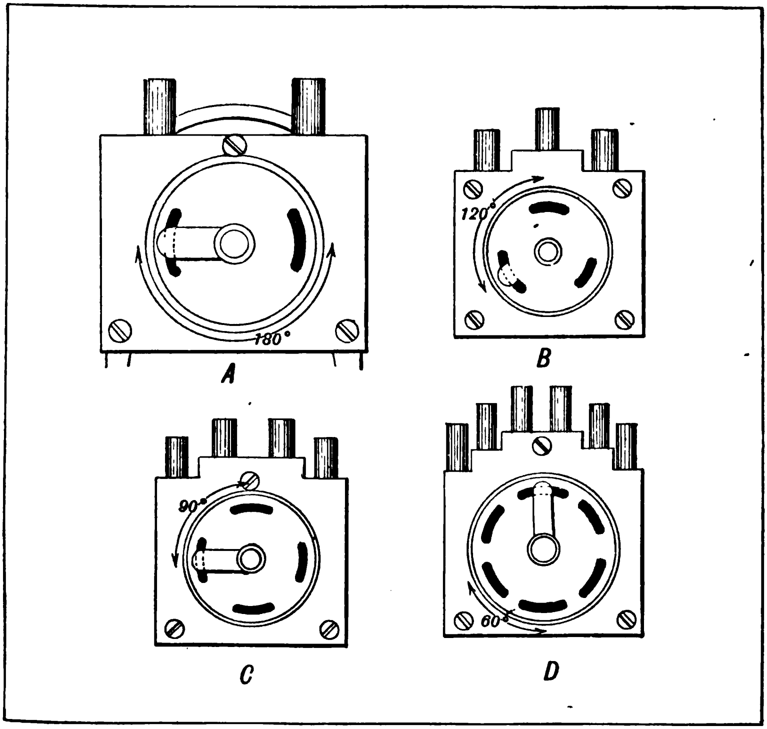


Fig. 93.—How Distributor Contacts are Spaced on Two, Three, Four and Six Cylinder Magneto.

a three-cylinder engine is used, as is sometimes the case in the two-cycle forms, the distributor segments are separated by distances of 120 degrees. If the distributor is used on a four-cylinder motor the segments are spaced 90 degrees apart, as shown at C. To fire a six-cylinder motor, six segments must be used and they

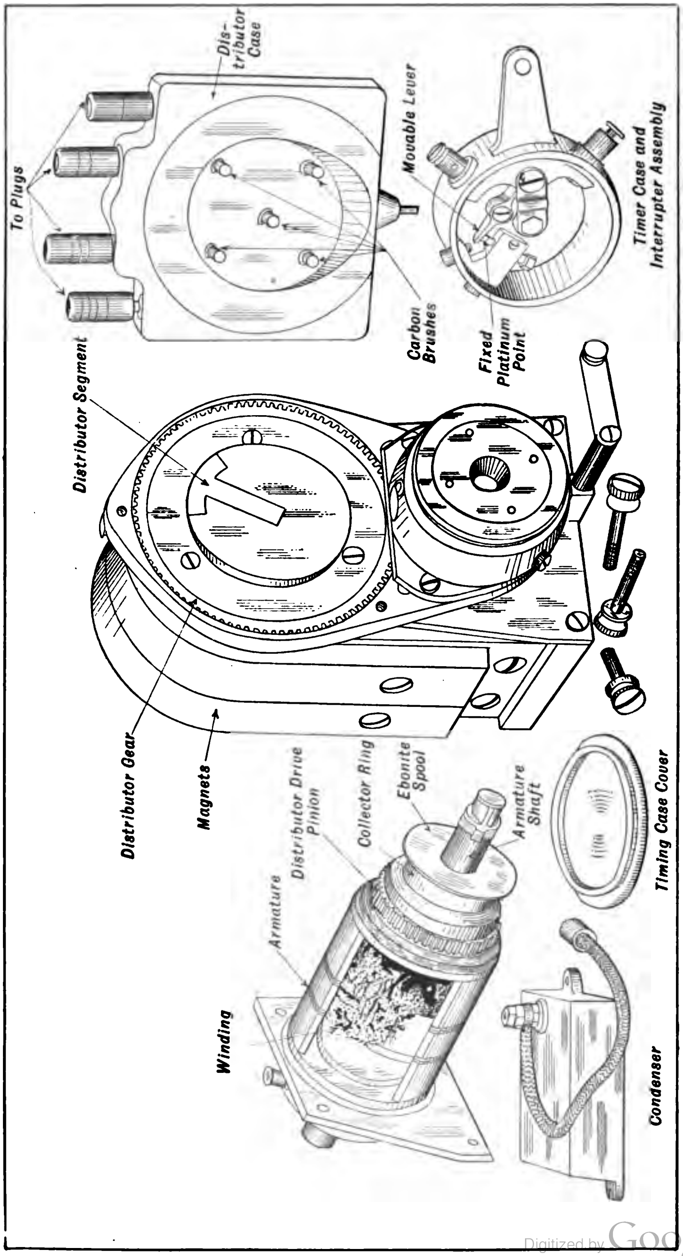


Fig. 94.—Partially Dismantled Four Cylinder Magneto Showing Important Parts of Current Producing and Distributing Element.

are placed 60 degrees apart, as indicated at D. The speed at which the armature of the magneto turns also varies with the number of cylinders. One- and two-cylinder forms turn at cam-shaft speed. The three-cylinder types when applied to a four-cycle engine turn at three-quarters the crank-shaft speed. The four-cylinder magneto armature is driven at crank-shaft speed, while that of the six-cylinder forms turn at one and one-half times crank-shaft speed. When used on two-cycle motors, the speeds given for four-cycle engines of the same number of cylinders should be doubled.

The important parts of a four-cylinder form of high-tension magneto are shown at Fig. 94, which is a view of a partially dismantled device. The armature assembly and one of the end plates by which it is supported are shown at the extreme left. Attached to the end of the armature shaft are the distributor drive pinion and the ebonite spool which carries the collector ring. The timer case and interrupter assembly are shown at the extreme right. Above it the distributor case is clearly depicted. When the device is assembled the end of the armature shaft protrudes through the housing at the lower part of the magnet assembly which is shown in the center of the group, with the end plate which carries the distributor gear and disk and one end of the armature in place. The distributor gear serves to drive a hard rubber plate in which the distributor segment is imbedded. When the distributor case is screwed in place, the carbon brushes, which are spaced around the interior of the distributor case, collect current from the revolving distributor segment and lead it to the spark plugs by suitable cables which run from the terminals at the top of the distributor casing.

Two systems of high-tension magneto ignition are used, one termed the true high-tension system, in which a current of high potential is delivered directly from the armature; the other is the transformer coil system, so termed because the current produced by the armature winding is of low tension and must be stepped up or increased in value before it is delivered to the spark plug by an induction coil similar in construction to that needed in battery-ignition systems. In the former apparatus the high-tension current is produced by means of a secondary winding on the armature itself, and as the whole apparatus is self-contained it is much more

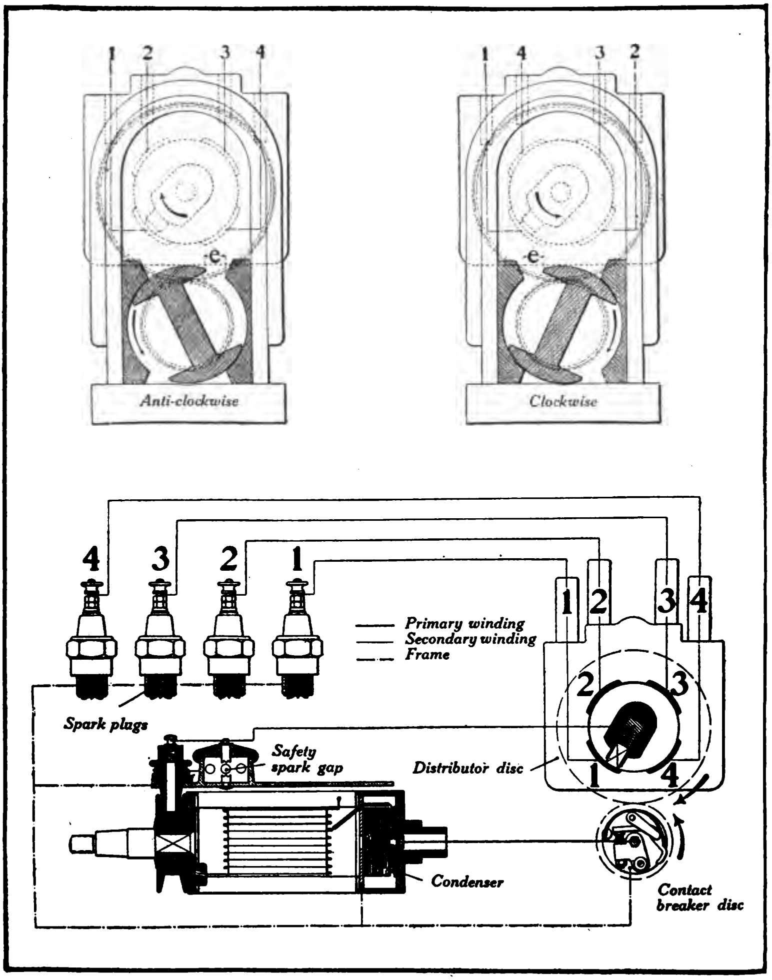


Fig. 95.—Simplified Wiring Diagram Showing Action of Bosch High Tension Magneto.

compact and simpler to install than those which need a separate transformer coil.

The simplified wiring system of a true high-tension magneto is shown at Fig. 95. The armature carries two windings, one indi-

cated by the heavier lines at the bottom called the "primary"; the other, composed of finer conductor, is known as the "secondary." One end of the primary winding is grounded, the other is joined to the fixed contact screw of the contact breaker. This end is also joined to one end of the secondary winding and the free end of the

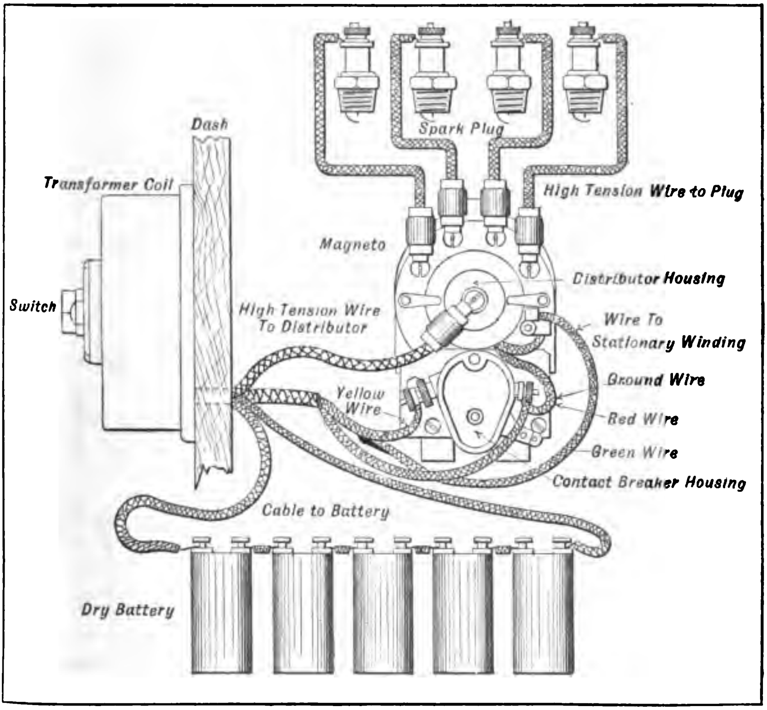


Fig. 96.—Wiring Diagram Outlining Method of Combining Remy Magneto and Transformer Coil to Form Ignition System for Four Cylinder Engines.

secondary winding is attached to the collector ring carried by the ebonite spool. When the contact points separate, a current is induced in the primary and secondary windings and is delivered to the center terminal of the distributor disk by the carbon brush which bears against the collector ring. The various segments of the distributor are connected to the spark plugs in the cylinders, and

every time the contact points separate a spark will be produced at one of the plugs because the revolving distributor brush will be in contact with one of the distributor segments.

The wiring of a four-cylinder magneto which employs a transformer coil is shown at Figs. 96 and 97. A set of batteries is pro-

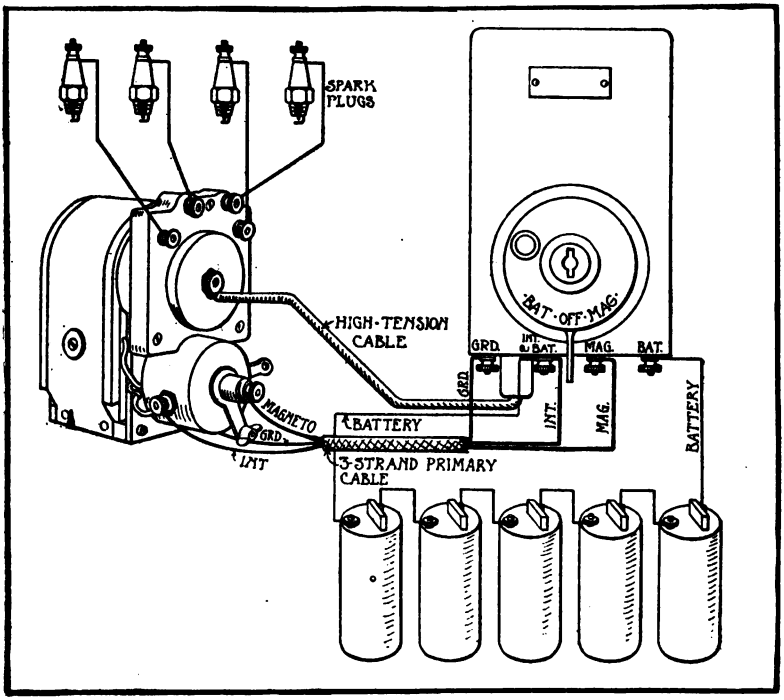


Fig. 97.—Typical Transformer Coil-Magneto System for Four Cylinder Ignition.

vided to furnish current for starting, as it is sometimes difficult to turn the motor sufficiently fast by hand to generate the proper amount of magneto current to insure prompt starting. The high-tension wire from the spark coil or transformer is led to the center of the distributor and the current is commutated to the plugs just as though the high-tension current had been produced in the magneto itself instead of in the transformer.

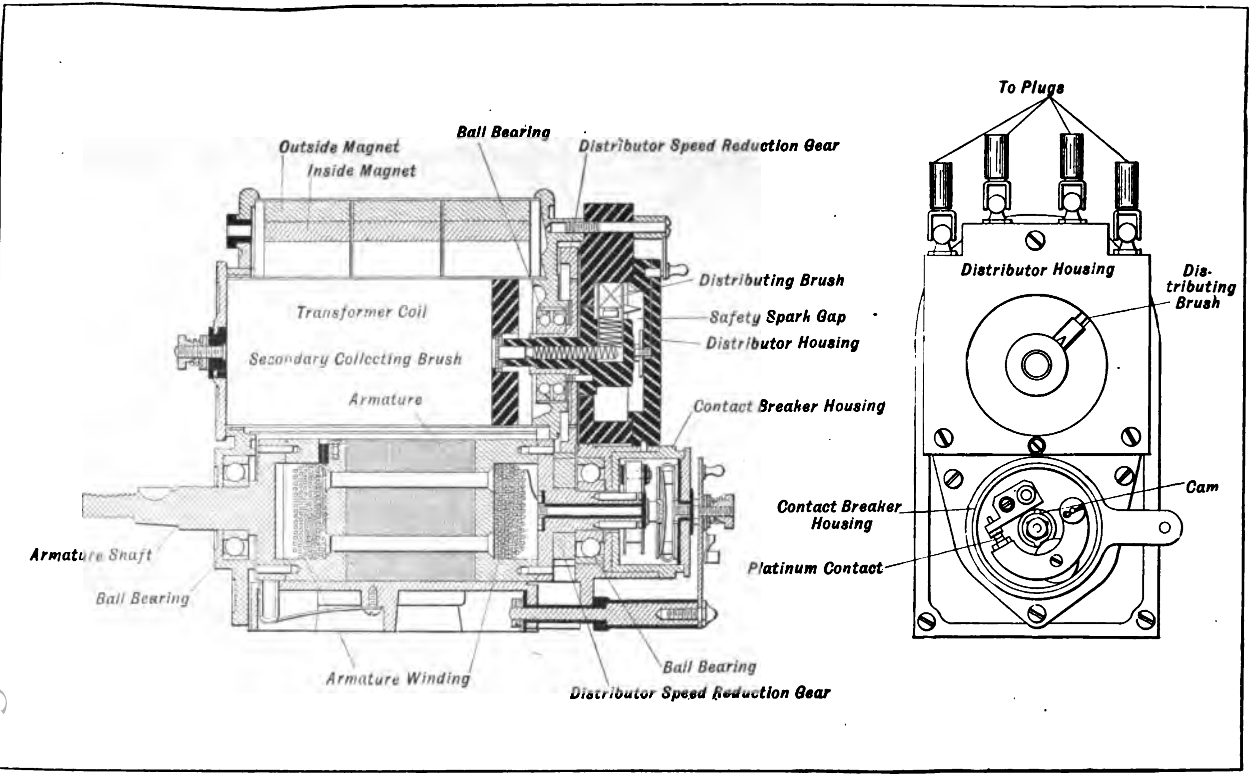


Fig. 98.—Defining Construction of Connecticut Magneto. A Form in Which the Transformer Coil is Placed Between Magnets Above Armature Tunnel.

The Connecticut magneto, which is a transformer coil type, is shown in longitudinal section and end elevation at Fig. 98. In this, the transformer coil is mounted between the magnets above the armature tunnel and the secondary current is applied directly to the distributing brush by means of a secondary collecting member which bears against a suitable terminal in the bottom of the coil

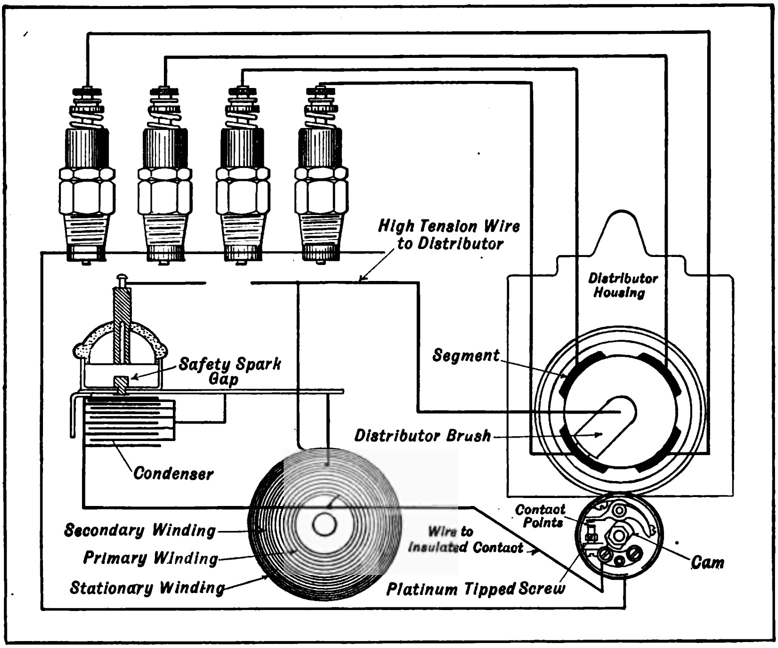


Fig. 99.—Showing Application of High Tension Principle in K. W. Four Cylinder Magneto.

casing. With this magneto the wiring is as simple as it would be with the true high-tension form and only five wires are needed in the external circuit. Of these, four secondary leads run direct from the distributor to the plug while the remaining one is a primary ground wire having a switch in circuit through which the primary coil current may be grounded instead of going to the transformer coil, thus stopping the motor.

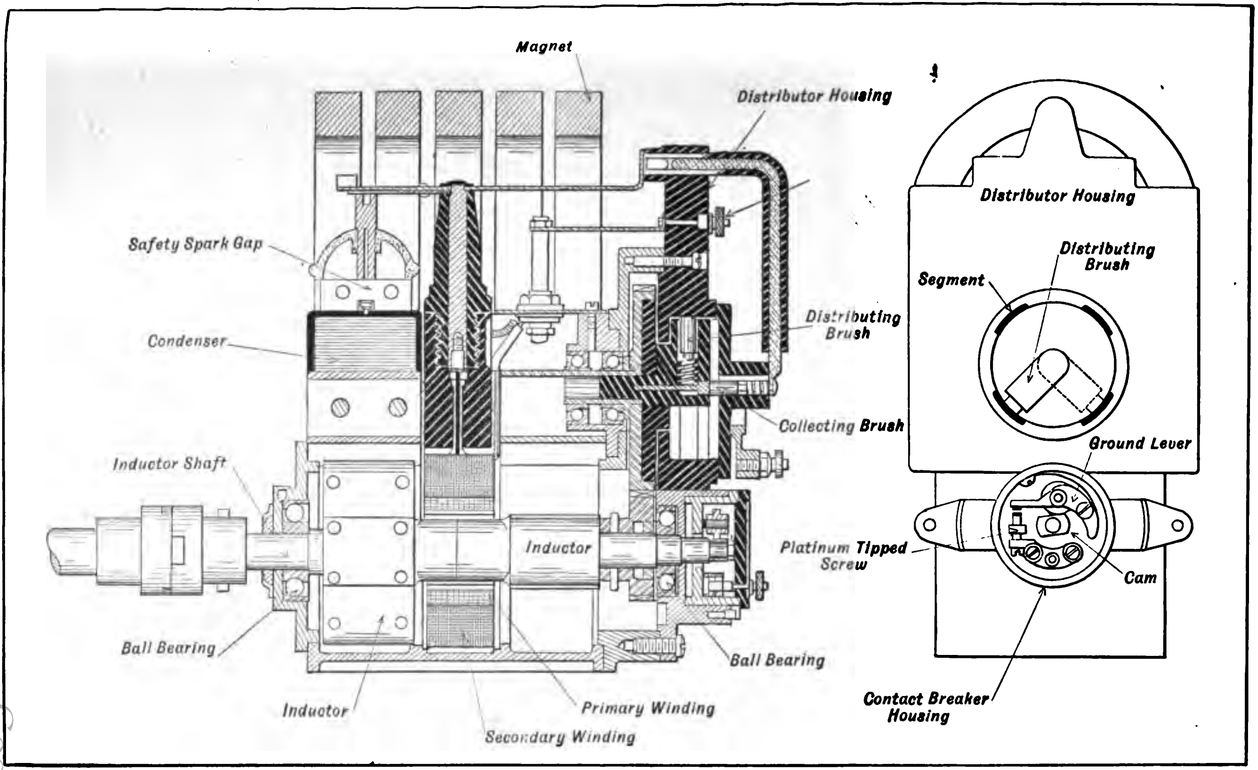


Fig. 100.—K. W. High Tension Magneto. A Distinctive Form Utilizing Stationary Winding and Revolving Inductor Elements to Produce Current for Ignition.

All magnetos do not employ a revolving winding. Some utilize a stationary coil of wire and use rotating inductor members to cause the lines of magnetic force to flow through the wire and generate a current therein. A simplified wiring diagram of the K. W. magneto, which is an igniter of this type, is shown at Fig. 99, while a sectional view of the device itself is presented at Fig. 100. The stationary coil is composed of two windings, a primary and a secondary, and is mounted in the center of the device so that the rotary inductor shaft passes through it, one inductor being placed at each side of the stationary coil. The secondary wire passes through the insulated electrode through a bridge or strap member which is connected at one end to the spark gap and at the other to a bent conductor which conveys the current to a revolving distributor arm.

When the contact points are separated by the cam a current of electricity is induced in the primary coil and transformed to a high-tension current in the secondary winding and is delivered to the spark plugs by the conventional form of distributor. Except for the stationary winding and the use of inductor pieces to reverse the lines of magnetism through the coil, the construction does not differ from the forms previously described. It is advanced that the stationary winding offers some advantages inasmuch as brushes are not required to collect the primary current.

The function of the safety spark gap is to take care of any excess current which might damage the insulation of the winding by allowing it to go to the ground. The air gap between the points has high enough resistance so that the spark will not jump it under normal conditions, but should the voltage become suddenly increased in value, as might be the case if one of the plug wires became disconnected, it will leap this gap in preference to overcoming the resistance of the insulation of the winding. The purpose of the condenser in a magneto is the same as that used in a coil, i.e., it is interposed in the primary circuit in such a way that it is in shunt connection with the contact-breaker points and absorbs any current which would tend to produce excessive sparking.

Simple Low Tension Magnetos.—Simple forms of magneto igniters have been devised for use in connection with stationary and marine engines that have not been adapted for service on the

automobile power plant. Two very simple magnetos are shown at Fig. 102, these having been used to some extent in tractor work as well as on the various forms of stationary power plants employed for miscellaneous duties in the shop or on the farm. The form at A has an oscillating armature instead of the usual form of rotating

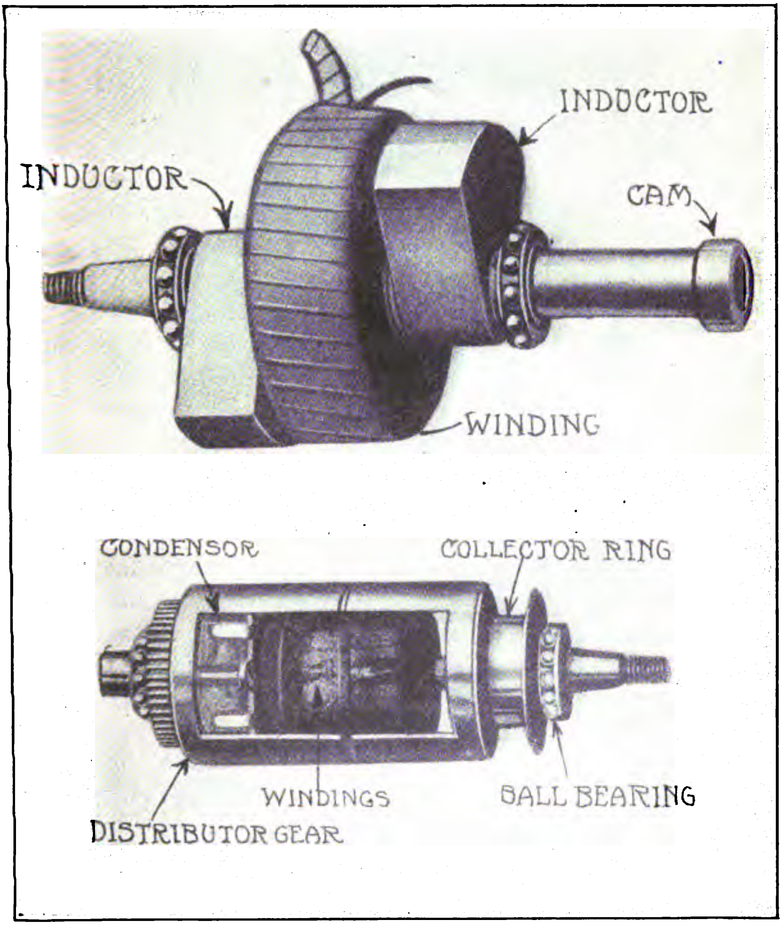


Fig. 101.—Rotary Inductor with Fixed Winding at Top of Illustration and Conventional Form of Rotating Winding Shuttle Armature at Bottom.

armature. The igniter points are mounted integrally with the device, the design being such that it is possible to bolt the entire igniter unit, including the magneto, to the combustion chamber just as the usual make-and-break ignition plate is. The magneto armature is oscillated by a lever actuated from a suitable cam or eccentric on the engine camshaft and the construction is such that when the armature is in the position of greatest current generation an adjustable trip member releases the trip finger attached to the armature which permits the coil springs to snap the armature quickly so that the lines of force produced by the permanent magnets are cut quickly, which means that a current of considerable intensity will produce a spark at the igniter points. It is understood that this must separate at the time of greatest current production in the oscillating armature member. A form of magneto based on the oscillating principle is well adapted to slow speed, heavy duty engines, but cannot be applied to the more rapidly moving camshaft mechanism of the ordinary multiple cylinder automobile power plant. The magneto shown at B is a simple generator having a permanent magnetic field and delivering a direct current, due to

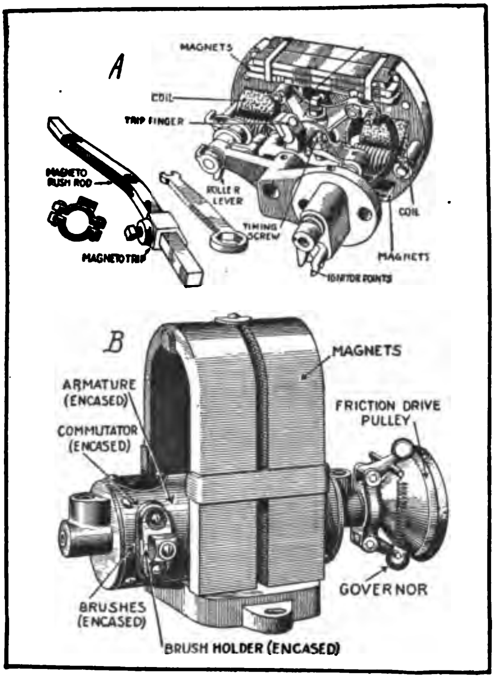


Fig. 102.—Oscillating Armature Low Tension Magneto with Incorporated Igniter Plate at A, Sometimes Used on Stationary Engines. B—Governed Type Direct Current Low Tension Magneto.

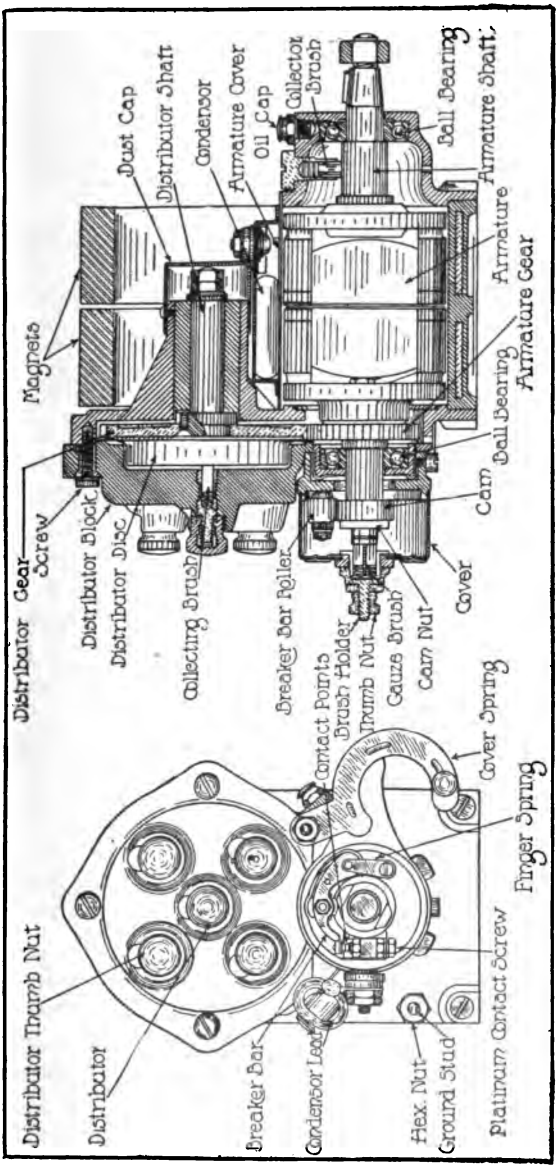


Fig. 103.—Sectional View Showing Construction of Splitdorf Low Tension Magneto.

the commutator and brushes used in connection with the revolving armature. This is driven through a governing mechanism of the usual fly-ball type, which interrupts the drive when the armature speed becomes excessive. A magneto of the form shown at B must be used in connection with an induction coil and timer just as batteries are, and the low tension current it produces must be intensified by a transformer coil.

High tension magnetos may be either one of two general forms, as shown at Fig. 13 (Chapter I), it being practically impossible to distinguish between them from external appearances unless carefully examined. The magneto shown at A is a transformer coil type, i.e., it generates a current of low voltage, which must be intensified by a separate coil of the non-vibrator form, the high tension coil current being brought to a central terminal on the distributor and from that point led to the various spark plugs by the rotary distributing brush. The true high tension magneto, which is shown at B, is a complete ignition system in itself, and does not depend on any appliances other than the spark plugs in the cylinders and a small grounding switch. A high tension current is delivered from the armature directly to the distributing member and no separate transformer coil is needed unless the magneto is used with a dual system. The parts that demand the most frequent inspection in a magneto are the more accessible ones, these being the breaker box, which houses the contact points, and the distributor, which is utilized to commutate the secondary current.

The construction of a Splitdorf transformer coil type magneto is clearly shown at Fig. 103. The longitudinal sectional view shows clearly the component parts of the device. The armature is wound to produce only low tension current, so the magneto must be used in connection with a separate transformer coil.

Another form of Bosch magneto which is practically the same in general principles as that previously described, except for slight differences in the contact breaker and distributor, is shown at Fig. 104. This is a smaller device, using two single horseshoe magnets, and is intended for small engines up to 30 H.P. The bigger magneto, with its three compound magnets, is more powerful and will produce a hotter spark, such as necessary to ignite the volume of

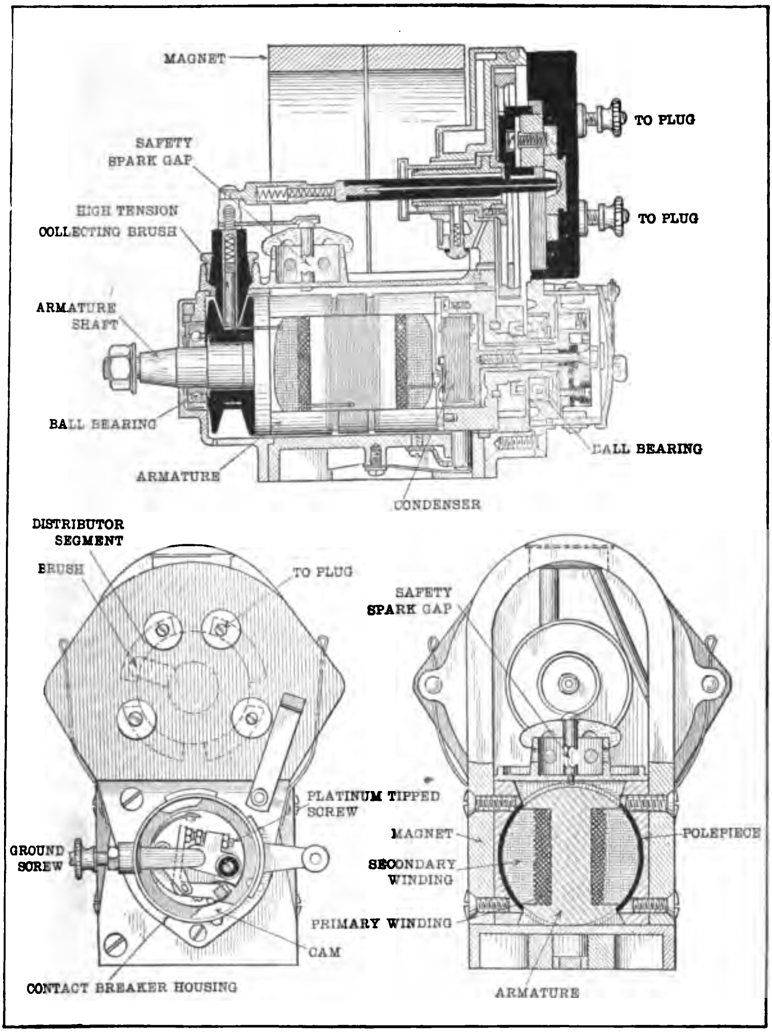


Fig. 104.—Views Showing Internal Construction of Bosch D U 4 High Tension Magneto.

gas in large cylinders. The Bosch DU4 magneto contact breaker and distributor are clearly illustrated.

Bosch NU4 Magneto.—Like other Bosch High Tension Magnetos, the type NU4 generates its own high tension current directly in the magneto armature (the rotating member of the magneto), without the aid of a separate step-up coil, and has its timer and distributor integral. By means of this construction the entire current generated in the armature is delivered at the spark plugs, absolutely without loss or lag, and the sparks so produced not only develop the full power of the engine, but are of such duration and intensity as to assure combustion of much poorer mixtures than can be ignited by any step-up coil system employing either batteries or low tension magneto as a current source. The distinct gear-driven distributor common to other types has been omitted in the "NU4" magneto, and in its stead is a double slipring combining the functions of current collector and distributor. The result is a considerable reduction in the number of operating parts, with a corresponding lessening of the possibilities of wear and noise, and the additional advantage of less weight.

As in other Bosch Magnetos, the current is inexhaustible and available at a very low armature speed. The wiring is the simplest possible, for, aside from the switch wire, the only cables employed are the four leading from the magneto to the spark plugs. It is important to note that as two of the four slipring brushes receive contact simultaneously and each is connected by cable to the spark plug in one of the cylinders, the secondary circuit always includes two plugs and the spark occurs in two cylinders simultaneously. The secondary winding is insulated from the primary and the two ends of the secondary are connected to two metal segments in the slipring mounted on the armature, just inside the driving shaft end plate of the magneto. The slipring has two grooves, each containing one of the two metal segments as shown at Fig. 105. These segments are set diametrically opposite on the armature shaft, i.e., 180° apart, and insulated from each other, as well as from the armature core and magneto frame.

The four slipring brushes, which are part of the secondary circuit, are supported by two double brush holders, one on each

side of the driving shaft end plate, each holder carrying two brushes so arranged that each brush bears against the slipring in a separate groove. Upon rotation of the armature, the metal segment in one slipring groove makes contact with a brush on one side of the magneto at the same instant that the metal segment in the other slipring groove comes into contact with a brush on the opposite side of the magneto. The marks "1" and "2," appearing

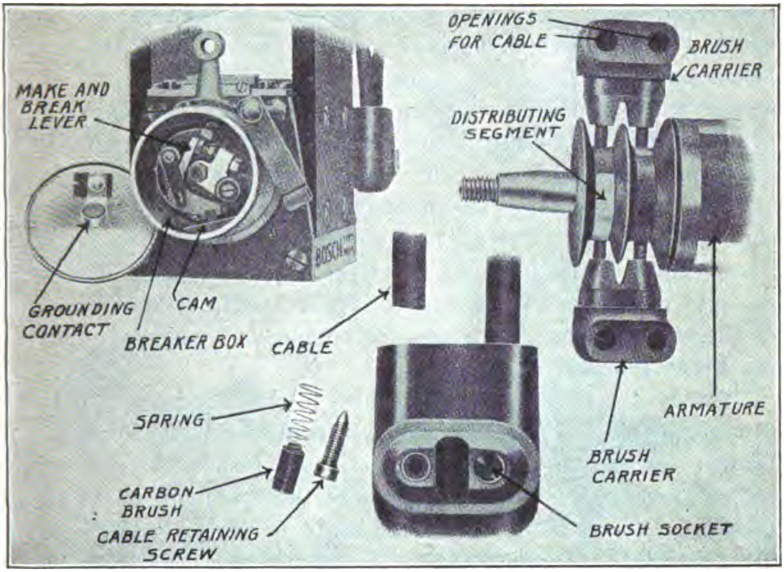


Fig. 105.—Contact Breaker and Distributor Arrangement of Bosch N U 4 High Tension Magneto.

in white on both brush holders, indicate pairs of brushes receiving simultaneous contact, those marked "1" constituting one pair, and those marked "2" the other.

As four-cylinder, four-cycle engines require two sparks per revolution of the crank shaft, and the type "NU4" produces high tension current only every 180° revolution of its armature shaft, the magneto must be operated at engine speed in order to provide the required ignition. It should be taken into consideration that, since

at each interruption of the primary circuit a spark appears at two plugs, the four effective or power sparks required for the four cylinders during every two revolutions of the crankshaft are accompanied by a like number of surplus sparks. Each cylinder receives alternately one effective spark and one surplus spark, the latter occurring exactly 360° behind the former.

In coupling the magneto to the engine, care should be taken that the platinum interrupter screws do not separate too late in their relation to the stroke of the piston. If they do, the surplus spark will occur when the inlet valve is open. With the magneto timed correctly, the extra spark always occurs during the exhaust stroke, when it has no effect on the operation of the engine. The brush holders fit directly into openings in each side of the driving shaft end plate and are held in place by the "L"-shaped catch springs. These springs are pivoted at one end, and at the other, or rounded end, carry a small boss which, when the spring is in position, rests in a notch in the brush holder and secures it in place. A slight downward pressure and outward pull on the rounded end of the catch spring disengages the spring and permits removal of the brush holder.

To connect the spark plug cables to the magneto, the slipring brush holders are removed and the brushes and brush springs withdrawn. At the base of each of the brush receptacles is a pointed cable fastening screw which is to be withdrawn, and in doing so it is essential to use a narrow-bladed screw driver in order to obviate the possibility of cracking the insulation of the brush holder. The ends of the cables are cut off square and pushed as far as they will go into the cable sockets of the brush holder. The pointed cable fastening screws are then returned to position, piercing the insulation and wires of the cable, thus securing it tightly and at the same time making perfect electrical connections.

Splitdorf Dixie Magnetos.—By adding eight and twelve cylinder models to its line of magnetos, the Splitdorf Co. is able to furnish magneto ignition for any automobile engine now on the market. The Mason principle on which the Dixie magnetos operate is a radical departure from ordinary magneto practice, and possesses many features of great interest. In the first place the rotating

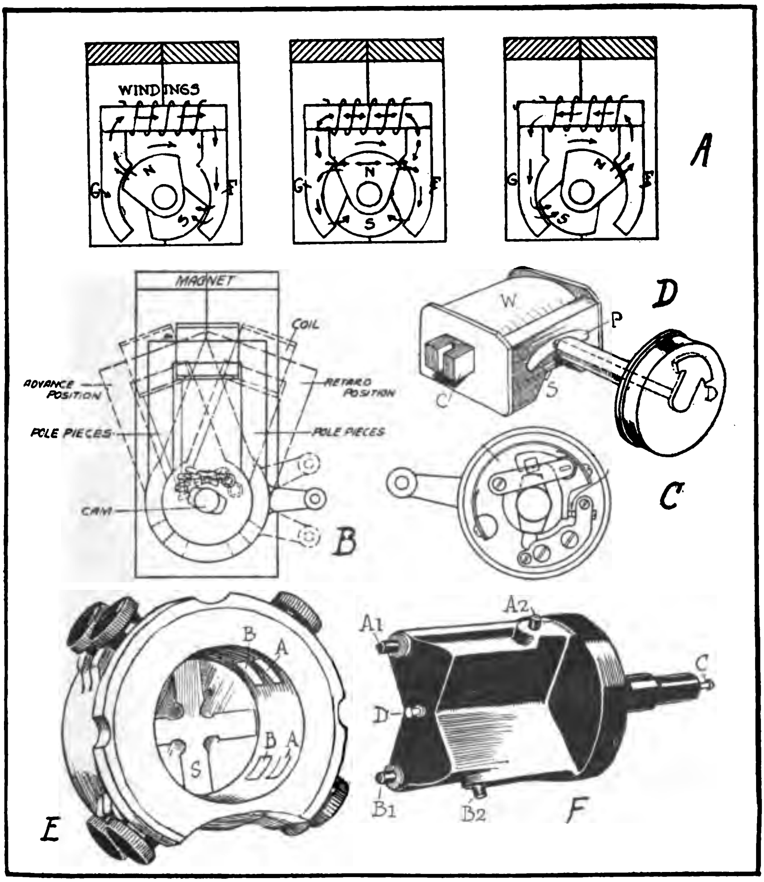


Fig. 106.—Diagram Explaining Action of Splitdorf "Dixie" Magneto at A. B—How Ignition is Advanced or Retarded. C—Contact Breaker Construction. D—How Secondary Current is Collected. E—Interior View of Eight Cylinder Distributor. F—Central Member of Distributor for Carrying Brushes.

shaft passes through the magnet poles instead of between them, and instead of carrying an armature on which the windings are placed, this shaft carries two solid polar extensions separated by a non-magnetic distance piece. Surrounding these revolving pole

pieces is a light laminated field structure consisting of two pole pieces F and G, Fig. 106, and a straight core on top. This core carries both primary and secondary windings. The principle of operation is that of sending magnetic lines alternately in opposite directions through the field structure. It will be seen that the pole extensions S and N are simply a means of carrying the magnetic lines from the main magnet to the laminated field structure, and that they do not change their polarity. In the four- and six-cylinder models each polar extension embraces about 90° of the tunnel.

Path of the Flux.—When the pole N is adjacent to G, Fig. 106, left, the magnetic flux flows in the direction of the arrows through the core of the windings from left to right. Continuing the rotation of the poles until they occupy a vertical position it will be seen that the field of the magnet is shorted through the pole pieces, cutting out the magnetic flux entirely from the core. Passing this point in rotation the pole extension N then comes into a position adjacent to F, causing the magnetic lines to flow once more through the core, but this time in the opposite direction, that is, from right to left. This reversal of direction of the magnetic flux is, of course, a necessary feature in any magneto and is the means of inducing the current in the windings.

In order to render this reversal easy and complete, the path for the magnetic lines is made up of thin iron laminations such as are used also in the construction of the armature in the ordinary magneto. The Splitdorf Co., however, make the claim for the Dixie construction that a point of great efficiency is obtained since the bulk of iron in the stationary field structure is so small, its size being governed entirely by magnetic requirements. The windings are remarkably small, being wound on a core of only 0.75 by 0.5 in., Fig. 106, D. The core is held in place by two screws passing through slots in the projecting ends. One end of each of the two windings is earthed. The open end of the high tension winding terminates in a contact plate P, Fig. 106, D, embedded in a rubber block at the side of the windings. The open end of the primary winding passes through a brass tube which leads to the base of the magneto, and so to the contact breaker, Fig. 107.

In dismantling, this wire is the only electrical connection to be loosened.

The Rocking Field—One of the most important features of the magneto is that the whole of the laminated pole structure, including the windings, can be rocked through several degrees. This rocking is accomplished by turning the timer arm of the circuit

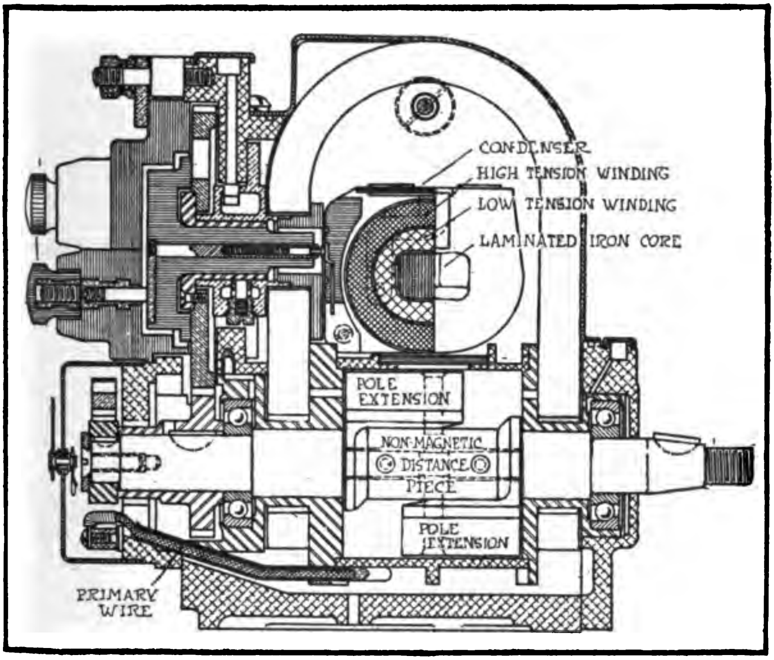


Fig. 107.—Sectional View of Splitdorf "Dixie" Inductor Type Magneto.

breaker in the ordinary way to advance or retard the spark. By means of this positive connection between the field and the circuit breaker it is possible to arrange the instrument to produce the sparks either advanced or retarded at the critical moment when the most magnetic lines are being cut. Hence the magneto has no one point in its spark position when the intensity of the spark is maximum or minimum; it is uniform all the time.

The distributor on the four- and six-cylinder models (Fig. 6) consists of an insulating block with a short spindle at one end of which is a spring brush bearing on the contact quadrant P on the windings. The high-tension current passes from this point to a radial arm on the distributor face and so to the outer terminals of the instrument. A good feature is the shortness of the path for the current from the windings to the terminals. A safety spark gap is included in the high-tension circuit at the base of the windings, and the condenser is located on top.

In the circuit breaker (Fig. 106, C) it will be seen that nothing revolves except the cam attached to the shaft. By this construction it is possible to adjust the contact points while running as the contact bases are stationary. The grounding terminal is insulated on the end of the spring clip which holds the breaker cover in position and as it bears on the center of the cover the ground wire is also stationary while moving the timer arm.

The four- and six-cylinder instruments are identical in every respect except the distributor and timing gears. In the eight- and twelve-cylinder models the shape of the rocking field and also the polar extensions are changed so that four sparks can be produced in each revolution. The laminated pole pieces embrace 50° each of the upper half of the tunnel, instead of 90°. In order to obtain the requisite number of magnetic reversals with these pole faces the main polar extensions are in the form of a cross, two ends being of N polarity and two of S.

The New Compound Distributor.—As it is practically impossible to obtain more than six contacts in a flat distributor disk of ordinary construction without a great risk of short-circuits caused by dangerously small electrical hazard distances, a particularly ingenious compound distributor (Fig. 106, E and F) has been designed for the eights and twelves in which the terminals are not arranged in one plane as in the four- and six-cylinder models, but in two parallel planes. In the compound distributor block on the eight-cylinder instrument the high-tension current is led through the center of the block from the brush C in contact with the windings to the brush D which bears on the center of the cruciform contact plate S embedded in the distributor box. This plate has no con-

nections with any terminals, but is a means of conducting the current in turn to the eight terminals as follows: In operation the plate S becomes "live" by contact with the brush D as before explained. Rotating over the ends of S are the two brushes A1

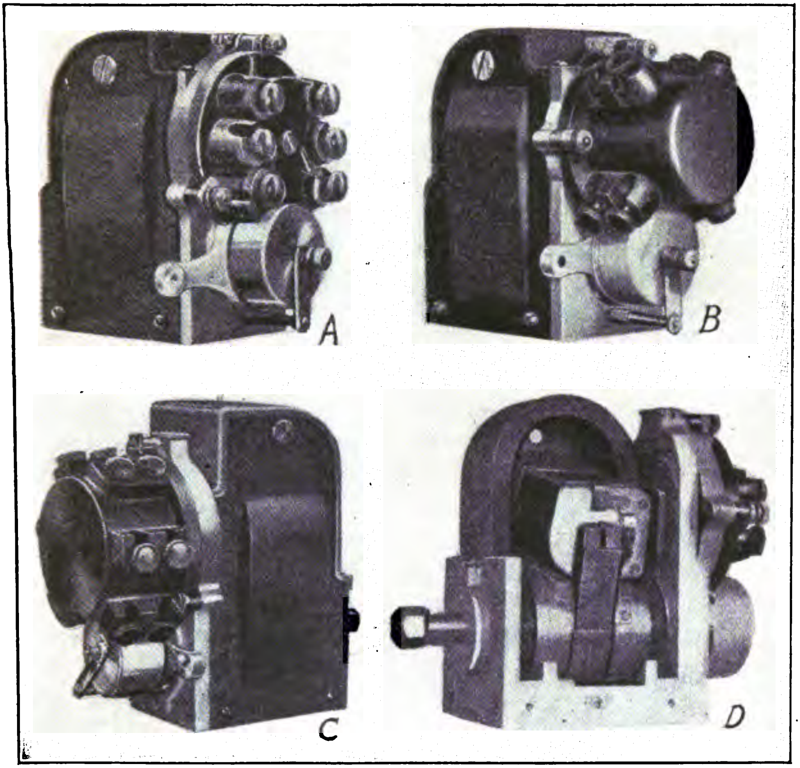


Fig. 108.—Forms of Dixie Magneto. A—Six Cylinder. B—Eight Cylinder. C—For Twelve Cylinder Engines. D—View with Cover and One Magnet Removed to Show Oscillating Coil and Pole Piece.

and B1 connected respectively to two similar brushes A2 and B2 in the side of the block. The path of the latter brush B2 includes the four contact pieces B connected to the four of the terminals, while the other brush A2 rotates in the path of the terminal plates A connected to the remaining four terminals. Now, since the two

brushes A1 and B1 are arranged 135° apart, it follows that eight sparks will be distributed to their respective terminals in one revolution of the distributor block in equal divisions of time. The timer gear is in the ratio of 2 to 1 so that this magneto runs at engine speed, an unusual feature of an eight-cylinder magneto. On the twelve the distributor gear ratio is 3 to 1, requiring a speed one and one-half times the engine speed.

The distributor for the twelves is identical in every respect except that the contact star at the base of the box is six-pointed instead of four, to supply the twelve terminals which are arranged in two layers, as shown in the external view (Fig. 108, C). By the use of the compound distributor block on the eights and twelves as many as 285 sparks of high intensity can be obtained per second. Owing to this high speed of spark production a double contact breaker having two breaker arms and contact points is used on the twelves.

Constructionally the Dixie magnetos are up to the present high standard of practice. The shaft runs on ball bearings, as shown at Fig. 107, tightly fitting brass side covers inclose the magnets and the whole instrument can be dismantled with no other tool than a screw driver. The magnet itself is in two parts and fits into place without bolting, having semi-circular notches which embrace the shaft bearing. Great accuracy has been used in the manufacture of the rotating pole extensions, the clearance between the ends and the stationary poles being brought down to the workable minimum. An interesting point in connection with the operation of these pole extensions is that end thrust is neutralized by the equal magnetic pull on both ends of the rotor. The compactness of the magnets can be realized from the dimensions which except in the height are practically identical in all models. The common width is 4.125 inches and the total length 8.375 inches. On the twelve the height of the magnet is 7.5 inches, being one inch more than the others so as to provide a stronger magnetic field.

The most popular form of magneto, if one can judge by the numbers of manufacturers using it, is the true high tension type with the revolving winding, though the low tension type using

transformer coils have also been used to a large extent. All magnetos do not have rotating windings, three makes, the K. W., Splitdorf Dixie and early models of the Remy utilize a fixed winding and rotary inductor. The inductor pieces are used to conduct

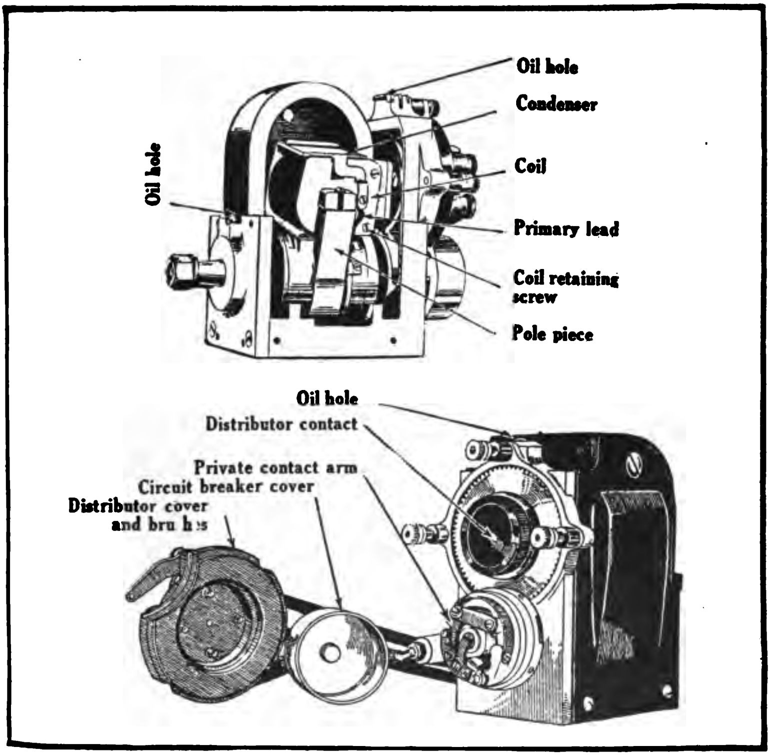


Fig. 109.—Splitdorf Dixie Magneto Used on 1916 Overland Cars.

the lines of magnetic energy through the winding and produce the current by cutting the turns of wire. In the armature shown in the lower portion of Fig. 101 the windings revolve in the magnetic field and generate the current. Another form of magneto which is used on but one make of car, the Ford, but which enjoys a wide distribution, is shown at Fig. 110 in connection with the

complete ignition system of the car. Sixteen coils of coarse conductor are carried by a fixed plate, which is bolted to the engine crank case, as shown at Fig. 16. A number of horseshoe magnets, not shown in the illustration, are carried by the ends of the flywheel and revolve in front of the fixed coils, the space between the magnet poles and the cores of the windings being just enough to provide clearance without danger of hitting the magnets. Owing to the large number of magnets and coils employed,

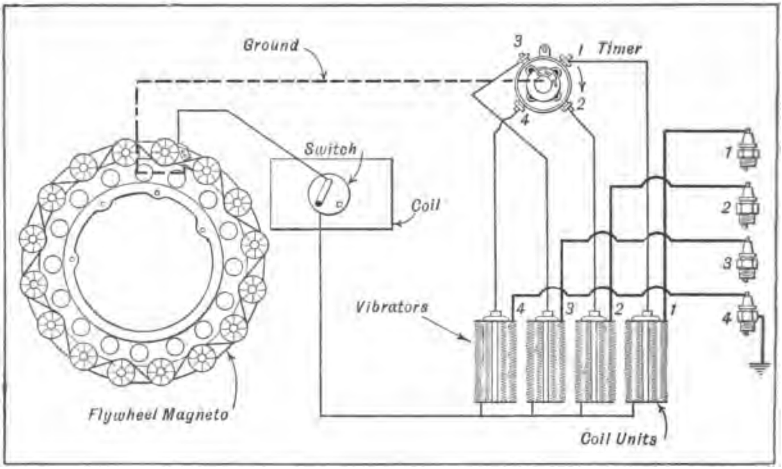


Fig. 110.—Unconventional Transformer Coil-Magneto Ignition System Used on Ford Cars.

a very strong current is obtained, which, while pulsating in character, is used in the same way as battery current would be through four individual vibrator coils, which are brought into circuit progressively by the rotary contact timer.

Transformer Coil Magneto Systems.—Methods of wiring typical transformer coil magneto systems are shown at Figs. 111 and 112 inclusive. At Fig. 97 all the parts of a system of this nature are clearly shown, and the wiring may be readily traced from the magneto or battery to the coil. It will be apparent that at the bottom of the single unit coil there are four primary terminals and one

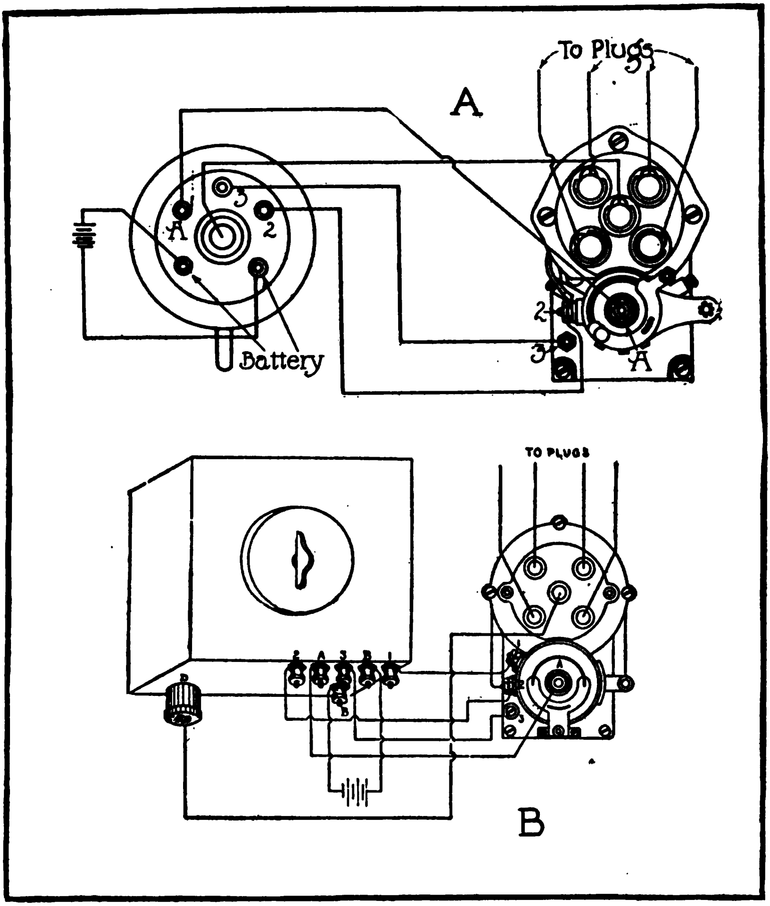


Fig. 111.—Typical Wiring Diagrams Showing Splitdorf Transformer Coil-Magneto Ignition Systems.

secondary terminal. A high tension cable runs from the secondary terminal, which is protected by an insulating member to the central distributing terminal on the face of the distributor. The terminal marked "Bat." is attached to the carbon of a 5 dry-cell battery, while the zinc terminal of the series is connected with a terminal marked "Int." and "Bat." From this same terminal a

wire runs to the terminal on the side of the contact breaker. The terminal on the face of the contact breaker is coupled to the coil terminal marked "Mag." A terminal on the coil marked "Grd." is attached to the grounding terminal on the magneto contact breaker. With this system, when the switch lever is pushed over to the side marked "Bat.," the current from the dry cell battery is conveyed to the magneto interrupter, from which it is led to the primary winding of the coil. The secondary current is distributed by means of the magneto distributor to the spark plugs in proper firing order. When the switch lever is shifted to the other side of the switch, which is marked "Mag.," the current for ignition is obtained from the magneto armature instead of the battery.

Two of the Splitdorf ignition systems are shown at Fig. 111, that at A being used in connection with a round type dash coil, while that at B is employed with a square type dash coil. The coil at A has but six terminals, that at B has seven terminals. In the coil at A the center terminal is used for the high tension current and is connected to the central terminal of the magneto distributor. Terminal A of the coil runs to terminal A on the magneto contact breaker face. The wire marked "2" runs to the terminal on the side of the contact breaker. A wire joins terminal "3" on the coil with the grounding terminal "3" on the magneto. The two remaining terminals of the coil, which are below the secondary terminals, are joined to the battery, which is conventionalized for the sake of simplicity. In the system shown at Fig. 111, B, the terminals on the magneto and those on the coil are likewise numbered, and there should be no difficulty in tracing these and making the proper connections if this diagram is used as a guide.

The Remy transformer coil system is shown at Fig. 112, the appearance and dimensions of the dash coil and the method of installation are clearly shown at A. It will be observed that at one end of the coil there are two terminals, one marked "Bat.," the other "R.," which are wired to the dry cell battery, as shown. On the back of the coil is the secondary terminal, clearly outlined at B, which runs to the center of the distributor. The magneto shown is intended for six cylinder ignition and therefore has six distribut-

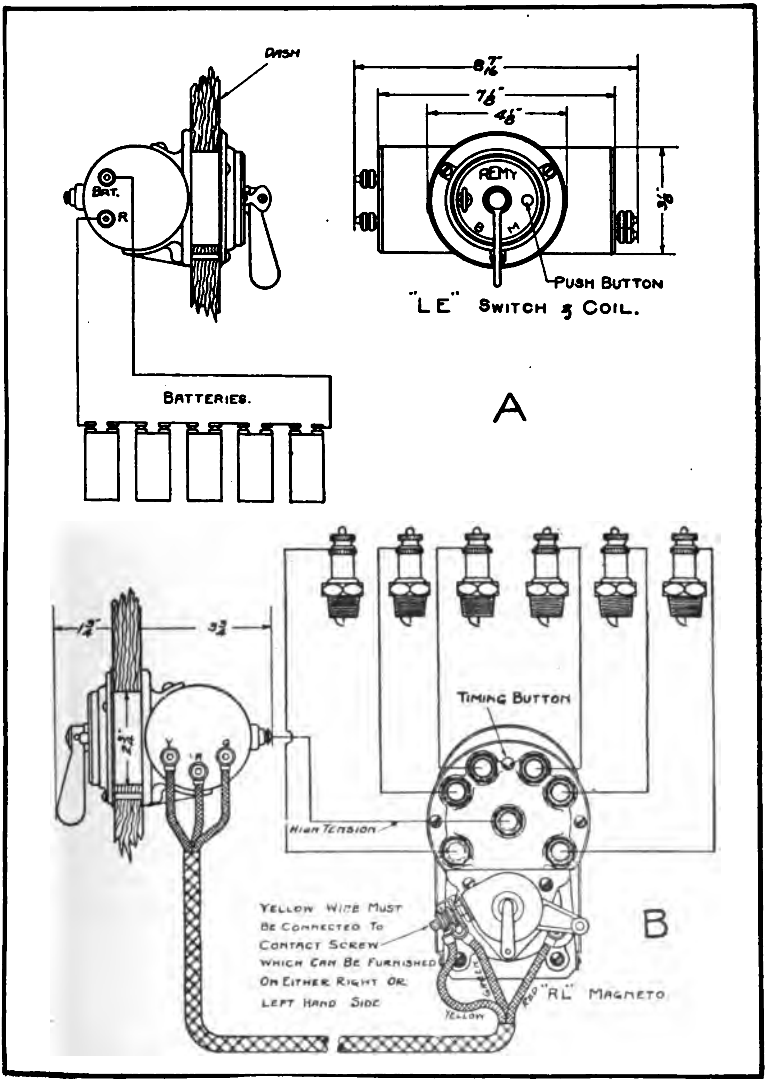


Fig. 112.—Wiring Diagram of Remy Type R. L. Magneto.

ing terminals, to be connected with an equivalent number of spark plugs. In order to simplify the wiring when the Remy system is employed, the primary wire group, which consists of three wires, has the insulation of each conductor a different color. One is yellow, one green, and the remaining one red. The red wire, which is attached to the grounding terminal on the magneto base, goes to the center terminal on the side of the coil that has the three primary terminals and which is shown at B. This would be the right side if viewed from the front, while the battery terminals are on the left side, if the coil is looked at from the switch end. The yellow wire is connected to the contact screw on the breaker box and goes to the terminal on the side of the coil nearest the dash. The green wire runs from the screw on the magneto base to the remaining terminal on the coil.

Dual Magneto Systems.—When the high tension magneto was first introduced it was looked upon in some quarters by conservative manufacturers and motorists with some degree of suspicion, as its reliability had not been thoroughly established. Sometimes difficulty was experienced in starting a large engine directly from the magneto because it could not be turned over fast enough with the hand crank to turn the magneto armature at sufficient speed to produce a strong spark. In order to provide an emergency system of ignition and one that could be used for starting, the makers of high tension magnetos evolved what are termed "dual systems." The magneto utilized is practically the same as that used in the simple high tension systems, except that the contact breaker had a battery timer added which was used to interrupt a battery current. The reason for adding the battery timer and not using the magneto contact breaker was that a short contact was necessary to obtain satisfactory operation from batteries, which the regular magneto contact breaker did not furnish. As the writer has previously explained, the points of a magneto contact breaker are kept in contact until interrupted by the cam. If these were used on a battery the current would be flowing through them all the time they were in contact, which would produce current waste. With the battery timer incorporated on the contact breaker the circuit is established only at the instant the spark is needed in the cylinder.

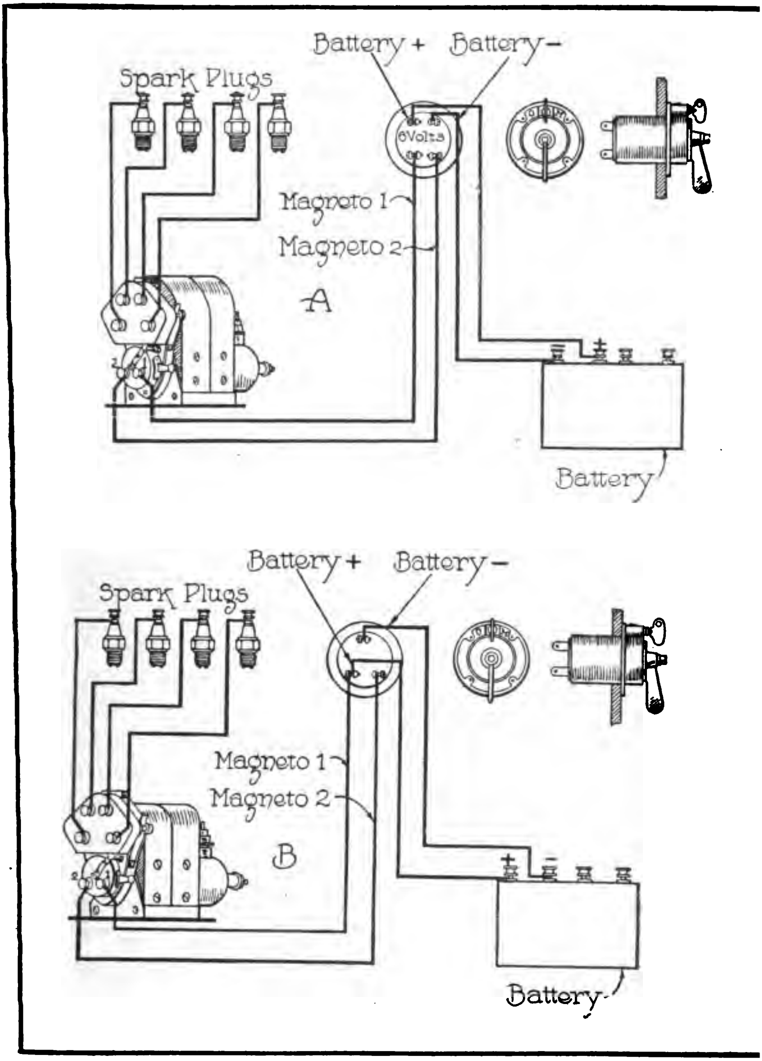


Fig. 113.—Wiring Diagram of Simms-Duplex Ignition Systems.

The systems shown at Fig. 113 are of Simms design and are duplex systems, the only difference being in the number of terminals provided on the coil. In the system at A four terminals are used. In that at B, but three are employed. The only difference in the wiring is the connections of the battery terminals. On the four terminal coils two of these are joined to the battery. On the three-terminal coil the wire that runs to point 1 of the magneto, as shown at B, also is joined to the positive terminal of the storage battery.

The Bosch Dual system, which is shown at Fig. 114, has six terminals on the back end of the coil. The coil is attached to the dashboard, as indicated, in the upper right hand corner, and carries the switch and the starting button on its face. The coil is of the vibrator type. The terminals are all numbered and the wiring may be readily traced, as the points to which they connect on the magneto are numbered to correspond. In this system, instead of using the usual high tension pencil connecting the collector brush to the center of the distributor, the high tension brush terminal 3 is joined to a terminal on the spark coil, while terminal 4 of the spark coil is joined to the central distributing brush 4 of the magneto. Terminal 6 of the coil is grounded, terminal 5 of the coil runs to one of the battery terminals, the other one being grounded. This leaves terminals 1 and 2 on the coil, No. 1 being connected to a terminal at the side of the battery contact breaker, while terminal No. 2 attaches to a terminal on the side of the magneto contact breaker. With a system of this kind or with either of those shown at Fig. 113, it is possible to short circuit the coil by pressing in on a starting button, whick makes the vibrator buzz even if the primary contact breaker on the magneto is not making contact. This permits of starting the engine directly on the spark when they are of the four or six cylinder form, providing they have not been stopped long enough for the gas to leave the cylinders.

Duplex System.—The "duplex" system differs from the "dual" system in the method of action. Instead of using a separate battery timer, as shown at A, Fig. 115, and an induction coil having its high tension or secondary lead connected to the central distributing brush of the distributor, the auxiliary brush

A on the magneto contact breaker, as shown at B, is used, and the winding on the magneto armature is used to intensify the current from the batteries in connection with a simple form of dash coil having only a primary winding, as the high tension current is delivered from the armature winding the same collecting brush serves to conduct the secondary current to the distributor in either case, regardless of the source of primary current. The "Duplex" system will not furnish ignition if the armature windings are defective, while the "Dual" system will. The latter is also more

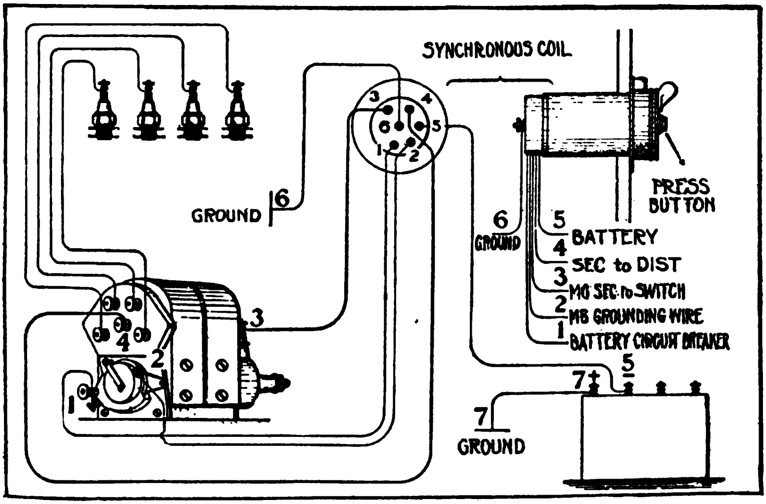


Fig. 114.—Wiring Diagram of Bosch Dual Ignition System.

economical of battery current. The wiring diagrams at Fig. 113 are of "Duplex" systems.

Two Spark Ignition.—Most racing and a few pleasure cars have been equipped with two spark magneto ignition systems, the idea being to secure greater power and speed due to the use of two spark plugs in the cylinder. While systems of this kind are rare, it may be well for the repairman to become familiar with the principles involved in case he should ever be called upon to install a two spark magneto or to make repairs on some speedster model

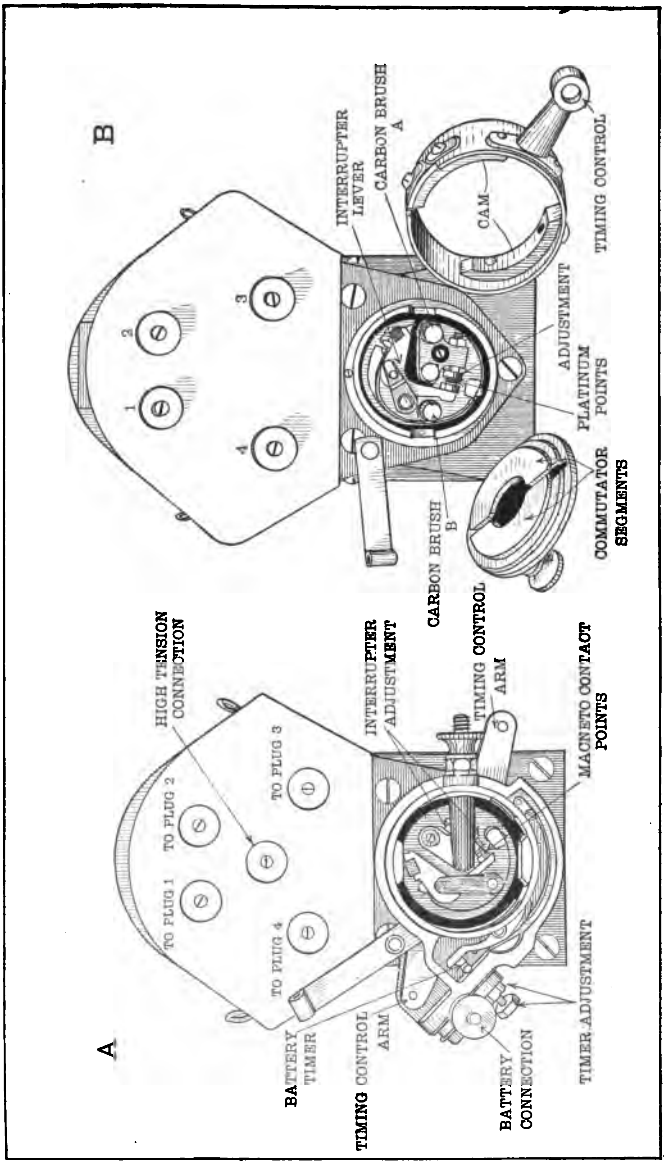


Fig. 115.—Contact Breakers for Bosch Magneto Double Ignition Systems. A—Arrangement for Dual Ignition. B—The Duplex Type.

so equipped. When a magneto is employed in connection with two spark ignition it is common practice to provide two separate distributors and in some cases a double wound armature having two sets of windings served by a common contact breaker. In the system shown at A, Fig. 116, a two spark magneto is employed

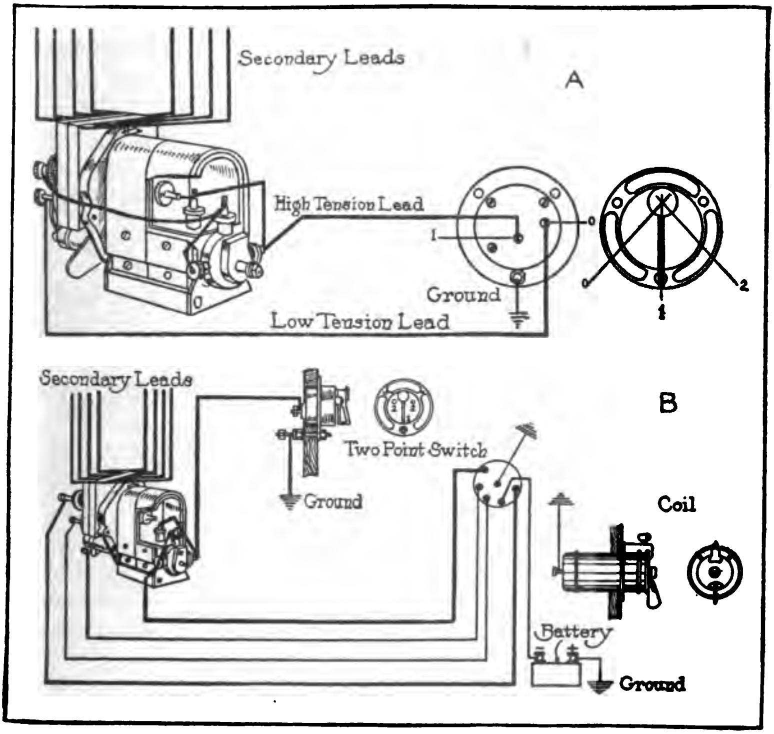


Fig. 116.—Two Spark Magneto Ignition System.

in connection with the simple dash switch wired as indicated, by which one may obtain the use of but one spark with the switch lever in the position shown and the double spark if the switch lever is rocked to the other extreme, or on the line marked "2." If the lever is swung to the left or on a line with that indicated "0," no spark will pass through the engine, as the magneto will

be grounded. The system outlined at B is that of a two spark magneto that can be used in connection with a vibrator coil and battery, as in the dual system previously described. In addition to the switch on the coil, a two point switch is placed on the dash in order to obtain single or double spark ignition as desired.

Magnetic Spark Plug Systems.—Other low tension ignition systems have been devised though they have never received wide application in which the moving mechanism needed to operate the igniter plates from the camshaft have been replaced with magneti-

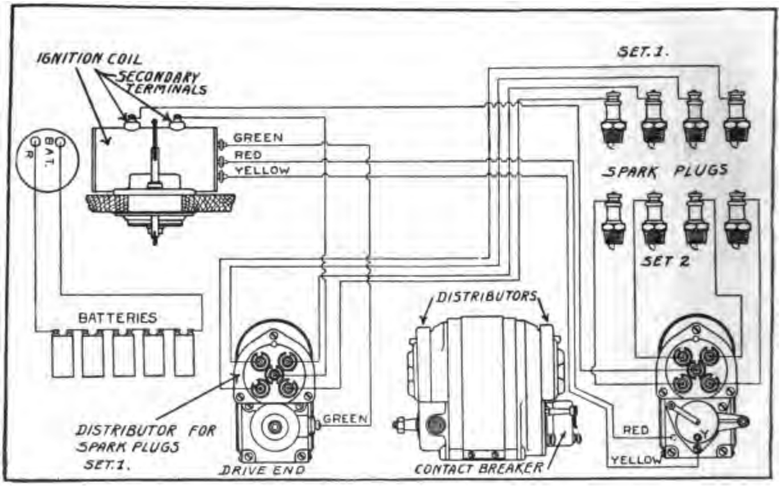


Fig. 117.—How Remy Two Spark Magneto is Wired in Ignition Systems.

cally operated spark plugs, the leading example of which is the Bosch shown at Fig. 118, A. This consists of three main parts, a supporting member which screws into the spark plug hole in the combustion chamber, an electro-magnet and oscillating mechanism. The electro-magnet contains a coil of wire D, and is protected by a cover B, and iron outer shell A. A cylinder H which is threaded at its lower end projects into the coil. A collar R forms the base of the magnet. The oscillating mechanism consists of a pole piece E, a horse-shoe shaped spring G, and an armature F. The lower part of the pole piece is provided with threads to fit the

hollow cylinder H, and is formed externally to be retained in the support K by a retaining nut or collar L. The supporting member has the upper half of hexagonal form the same as any spark plug body and is threaded to fit the spark plug aperture. A steatite insulating member J in connection with the packing gasket insures against loss of compression or explosive pressure.

The operation of the plug is very simple, as when the terminal P is connected to the scurce of current when the electricity passes

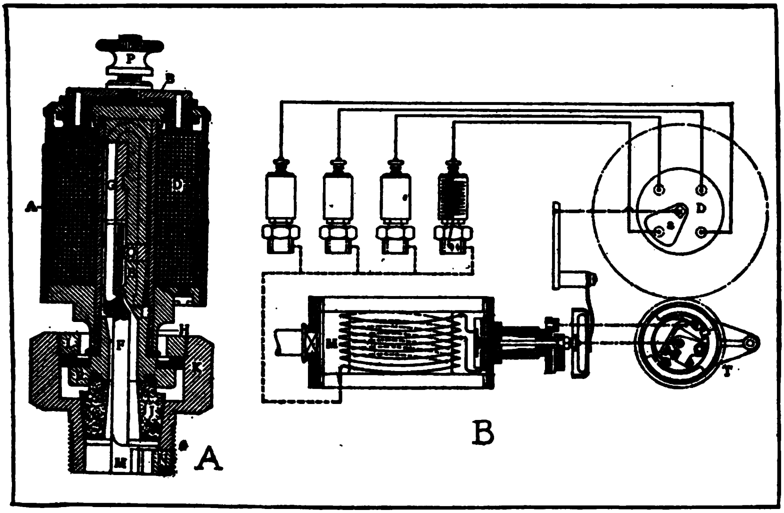


Fig. 118.—The Bosch-Honold System Magneto Plug at A and Method of Wiring at B.

through the coil it magnetizes the core E, which attracts the armature F, pivoted on a knife edge extending from E to the right, this separating the contact points M and N and producing a spark. A brass plug O is inserted in the core E so the armature will not stick to the pole piece due to magnetism. A spring G tends to keep the points M and N in contact. The point N is attached to the spark plug body and is V shaped, the other point on the armature being formed to fit into the V portion of M.

The complete ignition system is shown in diagram form at Fig.

118, B, and is very much the same as the wiring for a high tension magneto using jump spark plugs. In addition to the timer or contact breaker which is of the usual form, the magneto must include a distributing device which will allow the circuit to flow to the plug in the cylinder about to fire a charge. The distributor consists of four contact points carried by a body member of insulating material and a rotary distributor arm that makes contact with the different contact points in turn according to the firing order of the engine. The principal trouble apt to occur with the magnetic plug is short circuiting due to carbon deposits or accumulations of oil which will interfere with prompt action of the oscillating armature F. If the spring G breaks, the operation of the plug will be erratic and the engine will misfire. This system has received but limited application on automobile engines, but has been used to some extent in marine engine work so the repairman should, at least, be familiar with its principle of operation in order to have a reasonably complete knowledge of electrical ignition methods.

Impulse Starters.—Special forms of couplings, as illustrated at Fig. 119, may be used to drive the magneto armature. This provides a hot spark even when cranking slowly, as the armature speed is accelerated by a spring arrangement so the speed approximates that obtained when the engine is turning over under power. The device illustrated is known as the Eisemann impulse starter coupling. This may be attached to any model of Eisemann magneto and is said to have no effect upon its regular operation except at slow speeds, when it causes the armature to rotate in a series of jumps instead of at a uniform speed. These jumps cause the armature to cut the lines of force of the magnets quickly, or at the same speed that it does when the motor is revolving swiftly, so that a hot spark is generated. This removes any necessity for auxiliary battery ignition for starting on heavy duty motors, for a hot fat spark is generated at any speed, regardless of how slowly the crank is turned. The coupling consists of a driving tube A in the center and a driven cup B inclosing the device, the two being connected by a spring. Within the driven cup is a loose ring C, known as the trigger, this ring having a lip which extends

through a slot on the periphery of the cup. At the bottom of the coupling is a notched bar, so positioned that as the cup revolves the notch registers with the slot in the cup, so that the trigger lip drops down by gravity and thus locks the cup against rotation. This is the position shown in the view at C. On the outside of the trigger ring is a cam which engages a corresponding cam cut in

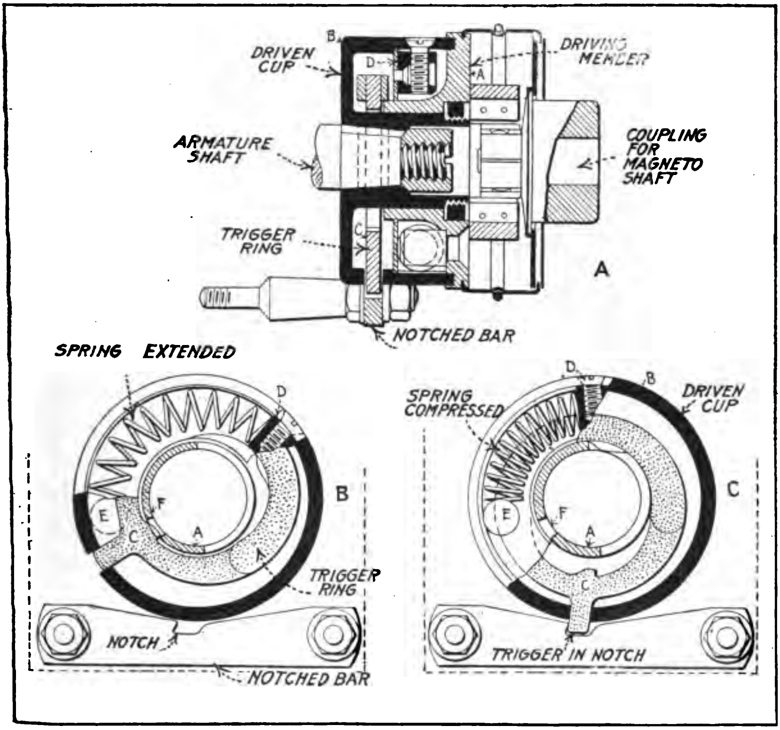


Fig. 119.—Diagrams Explaining Action of Eisemann Impulse Starter.

the driving tube. When the lip has engaged the notched bar and the cup ceases to rotate the driving tube continues to turn. This turning compresses the spring which is seated against a driving pin on the tube and a block fixed to the cup. At a predetermined point the cam on the trigger ring engages that on the tube, and lifts the

trigger far enough for the lip to disengage the notched bar, so that the compression of the spring spins the cup around in a clockwise direction.

The magneto armature is connected with the cup, and so as the cup spins around the armature is given a quick twist, producing a hot spark. At slow speed, as the cup revolves it is caught again and again by the trigger, but when the motor fires, the speed is so increased that the trigger ring, by its own weight, becomes a

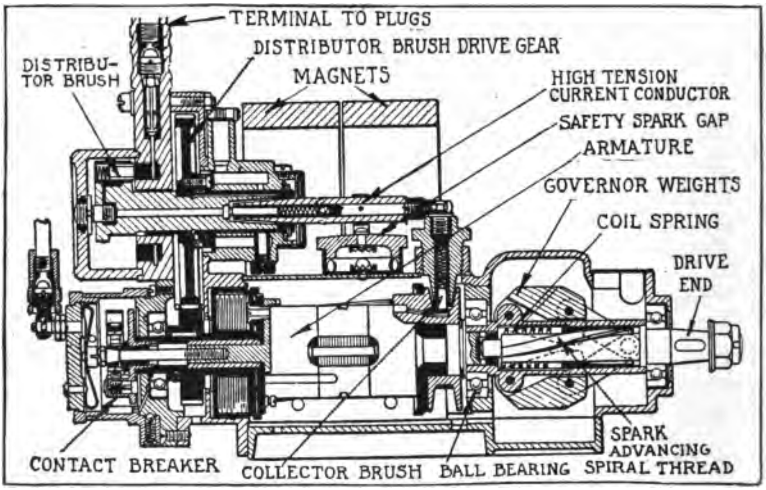


Fig. 120.—Sectional View of Eisemann High Tension Magneto Showing Automatic Spark Advance Mechanism.

ring governor, and centrifugal force keeps it from dropping down the slot. In this state the coupling acts as a dead connection between the drive and the armature, a small lug on the inside of the trigger ring, at the point where the lip juts out, engaging a notch in the driving tube, and this providing a positive drive as long as the speed is maintained. The device includes the standard Oldham coupling for connection with the shaft, as shown in sectional view at A.

Automatic Spark Advance.—A sectional view of a true high tension magneto, the Eisemann, is shown at Fig. 120. The spark

time is advanced and retarded on most magnetos by rocking the contact breaker back and forth by a suitable mechanical connection with the spark lever on the steering wheel. In the Eisemann magneto outlined an automatic spark control or advancing mechanism, which increases the lead of the spark as the engine speed increases, is included. The operation of this automatic timer is very much the same as that of the Delco automatic spark advance, previously described. The governor weights are carried by a sleeve or quill mounted on an extension of the armature shaft, which has a

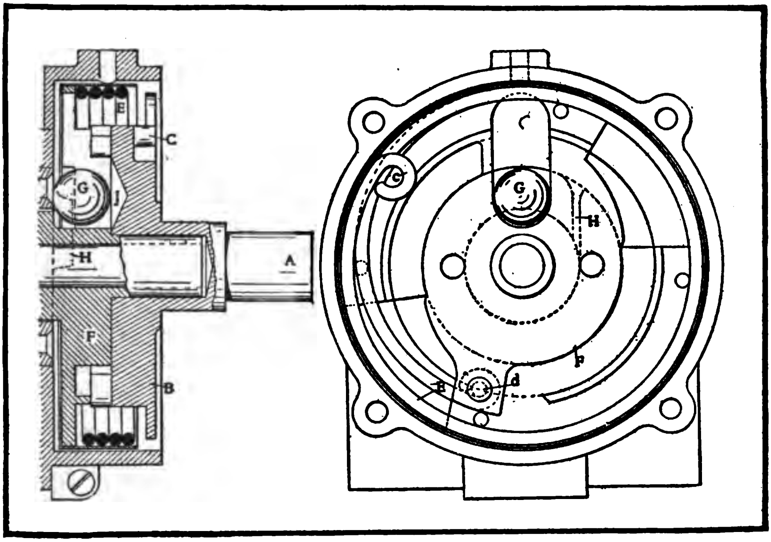


Fig. 121.—Sectional Diagram Showing Construction of Herz Governor Coupling to Secure Automatic Spark Advance.

rectangular block sliding within it. This block is threaded for receiving a spirally cut shaft, which is driven by direct connection with the engine through some form of gearing. The governor weights are attached to the sliding block by means of links, and as the shaft is revolved the weights tend to spread apart, and as they do the block is made to slide in the quill. In so moving it travels along the threaded shaft, which results in slightly rocking

the block. As the block oscillates it carries the quill, in which it works, forward slightly and also the armature shaft to which the quill is fixed. The armature is thus advanced and also the commutator, which is attached to the front end of the armature shaft. As the speed increases the governor weights fly farther out and advance the time of ignition. When the speed diminishes the weights tend to close up, this being assisted by the action of a coil spring, against which the governor weights work at all times. An automatic spark advance may be obtained from 18-57 degrees with this construction.

Herz Governor Coupling.—In this automatic advance coupling, the driving relation between the driving member B and the armature driving plate B is determined by the position of the steel ball G. As the speed increases, the ball moves outward in its guiding groove because of centrifugal force and the armature driving member is displaced in its angular relation to the driving plate B so that the spark time is advanced. The coil spring E controls the relative angular displacement of the coupling parts.

Low Tension Magneto Troubles.—Trouble is sometimes experienced with the low tension magneto, which is shown in section at Fig. 122. The form shown uses plain bearings and as these require considerable lubricant it is possible for the collecting brushes or armature winding to become oil soaked which interferes with proper delivery of current. It is also important to time the low tension magneto so the contact points of the igniter plate in the cylinder will separate when the armature of the magneto has attained its position of maximum current generation. This will be considered in detail in connection with the high tension magneto as will other magneto troubles, so it is not necessary to consider them at this time. It is important that the contact brush shown bearing against the side of the armature and the contact member A, be making a positive connection with the parts they are intended to bear against. Failure of the low tension magneto to deliver current is usually due to poor contact at these points which may be produced by particles of foreign matter or which may result if the springs maintaining the parts in contact have lost their elasticity. Generally the trouble is gummed oil

which is easily removed with gasoline. Sometimes the current delivered by the armature short circuits because of a cracked or oil soaked insulator which carries the contact rod C. Ignition troubles will also result if the wiring to switch or bus bar is defective or if connections are loose (Fig. 123).

High Tension Magneto Troubles.—In case of trouble with a magneto the point to be determined, first of all, is whether the fault is with the current generator, if it is a true high tension

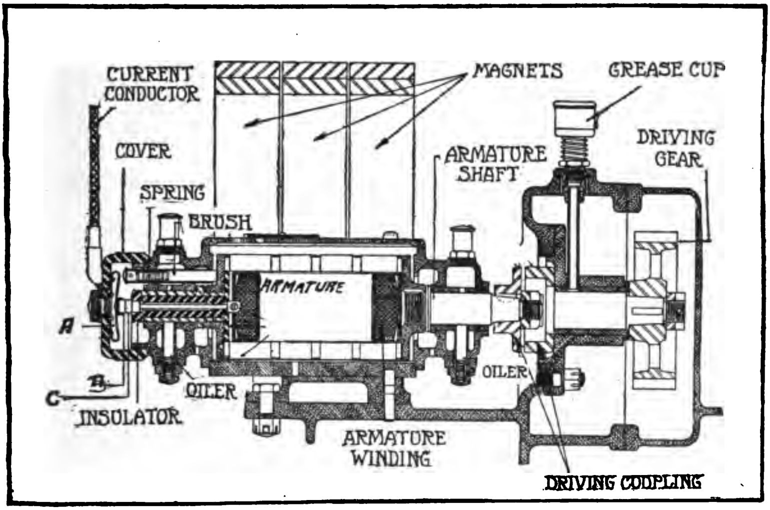


Fig. 122.—Sectional View Showing Construction of Locomobile Low Tension Magneto.

form or in the plugs, or in the event of a transformer coil being employed, if that member is at fault. In cases where only one cylinder is firing irregularly the fault is very likely to be with the spark plug in that cylinder. The common troubles of spark plugs and the method of repairing them have been previously described. After the spark plugs have received attention the cables must be tested to make sure that the insulation is not injured in any way or that the metal terminals at the end of the cable do not come in contact with any metal parts of the

motor or magneto. If the ignition fails suddenly, one can suspect a short circuit in the grounding cable, which is connected to the nut on the magneto contact breaker and which serves for switching the ignition off. This may be easily ascertained by removing the cable from the magneto and seeing if its removal enables the magneto to run correctly. A spark leaping the gap in the safety device indicates a broken wire or one that has become disconnected either from the plug terminal or from the distributor terminal.

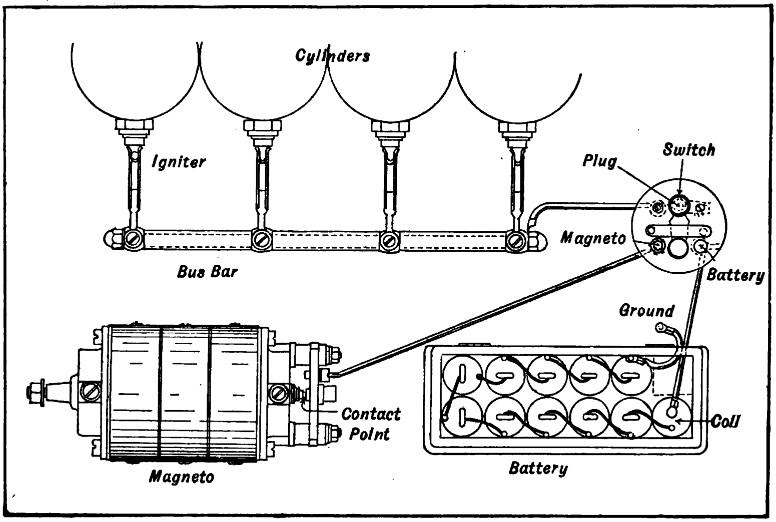


Fig. 123.—Low Tension Ignition System for Four Cylinder Motor, Utilizes Battery and Magneto for Current Production. Note Simple Wiring—All Conductors Convey Only Low Tension Current.

If the cables and plugs are in good condition and the engine works irregularly, it is apparent that the trouble is in the magnet if it is an ignition fault. In event of this, the most important thing to do is to make sure of the proper interruption of the primary current. The spring holding the cover of the contact breaker in place should be moved sideways and the brass cover taken off. It is then important to see if the screw holding the contact breaker to the armature shaft is tight. If this is found to be set up properly the

next thing is to make sure that the contact breaker points are in contact when the bell crank lever is out of contact with the cam in the sides of the breaker box in the type Bosch DU-4 or away from the fibre cam rollers in the type D-4. It is also important that the platinum points are separated by the proper distance, about .5 millimeter, where the lever C F at A, Fig. 124, is in contact with the cam. If the points are too far apart they should be brought nearer together by loosening the lock nut on the ad-

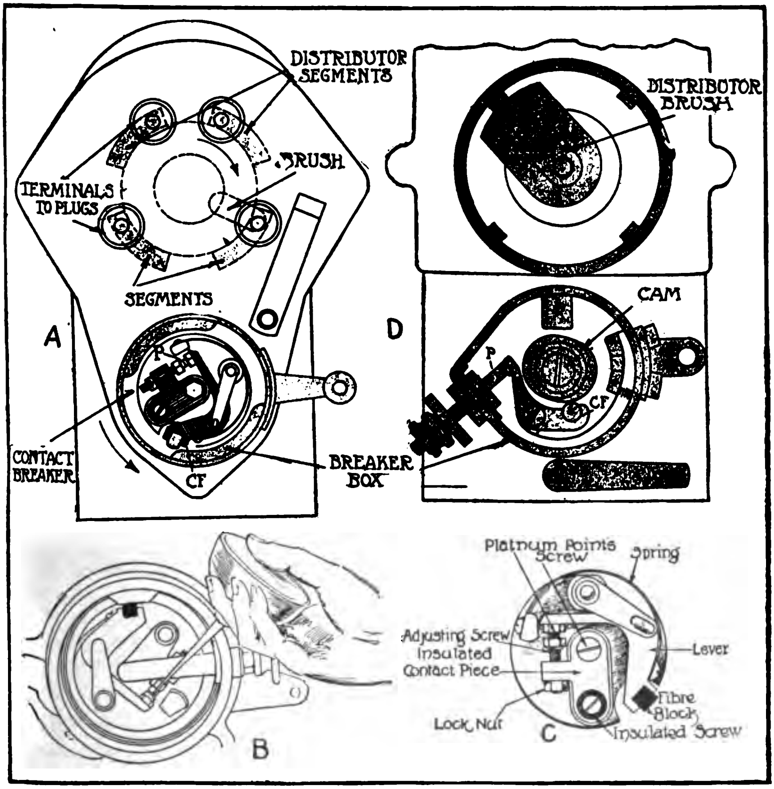


Fig. 124.—Construction of Bosch Contact Breaker Made Clear at A. B—How to Clean Contact Breaker Points. C—Bosch Contact Breaker Assembly Removed from Armature. D—The Remy Contact Breaker.

ısting screw shown at C, and screwing it up to lessen the ifference, or to screw it back and open the gap if it is not suffi- ent. The platinum contact points must also be cleaned, any irt or oil being easily removed, as shown at B, by gasoline

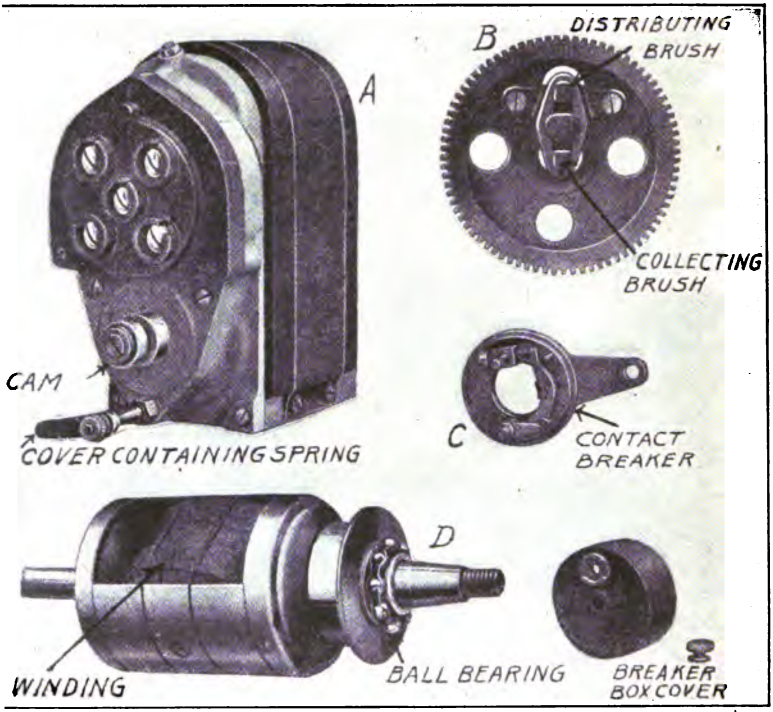


Fig. 125.—Remy Magneto Using Conventional Rotary Winding on H or Shuttle Armature and Parts of Contact Breaker and Distributor.

uirted on them from a small hand oil can. In case the contacts ·e uneven, pitted or blackened, they must be smoothed with a jew- er's fine cut file. After continued use, if the platinum points ıve worn down the platinum-pointed screw must be renewed. It also important to make sure that the high tension current col- cting brush is in contact with the collector ring, and that the

conducting pencil makes proper contact with the brush, against which it bears. The interior of the distributor must be clean and free of metallic or carbonaceous matter. The distributing brush must bear positively against the distributor section and the interior of the distributor should be smooth and all contacts clean and bright.

Mention has been previously made of making sure that the screw which keeps the contact breaker assembly in proper relation with the armature shaft is tight, which calls for careful examination. If this screw is loose, the contact breaker assembly will not move in proper timed relation with the armature; in fact, it may not move at all, which will prevent the contact point from separating and which will also result in failure of the ignition. If everything appears to be all right about the magneto, the timing should be verified to make sure that the spark is occurring at the right time in the engine cylinders. It is easy to tell if the magneto is producing a spark of proper intensity by uncoupling a spark plug conductor and holding it a short distance away, not more than ⅛″ from the terminal. If a magneto is functioning properly a spark will jump the air gap thus created.

At Fig. 124, D, the contact breaker and distributor construction of the Remy magneto is shown. It will be observed, in this case, that the contact breaker assembly does not rotate, as in the Bosch, but that a rotating two-point cam is attached to the armature shaft and interrupts the contact between the points P by bearing against the end of the bell crank CF. The instructions given for care of the Bosch magneto apply just as well to this device. Realizing the importance of having the gap between the contact breaker points of the proper amount, the magneto manufacturers furnish gauges which are to be used for testing this gap. That shown at Fig. 126, A, is for use with the Eisemann magneto. With the contact breaker removed, as indicated at B, the contact points C-4 should be together as indicated. When the gauge is inserted in the hole C-7 it will indicate the correct amount the point should be separated. The gauge at Fig. 126, C, is merely a piece of thin sheet steel of the proper thickness which is used as indicated when the points are separated by the bell crank lever riding on the cam block.

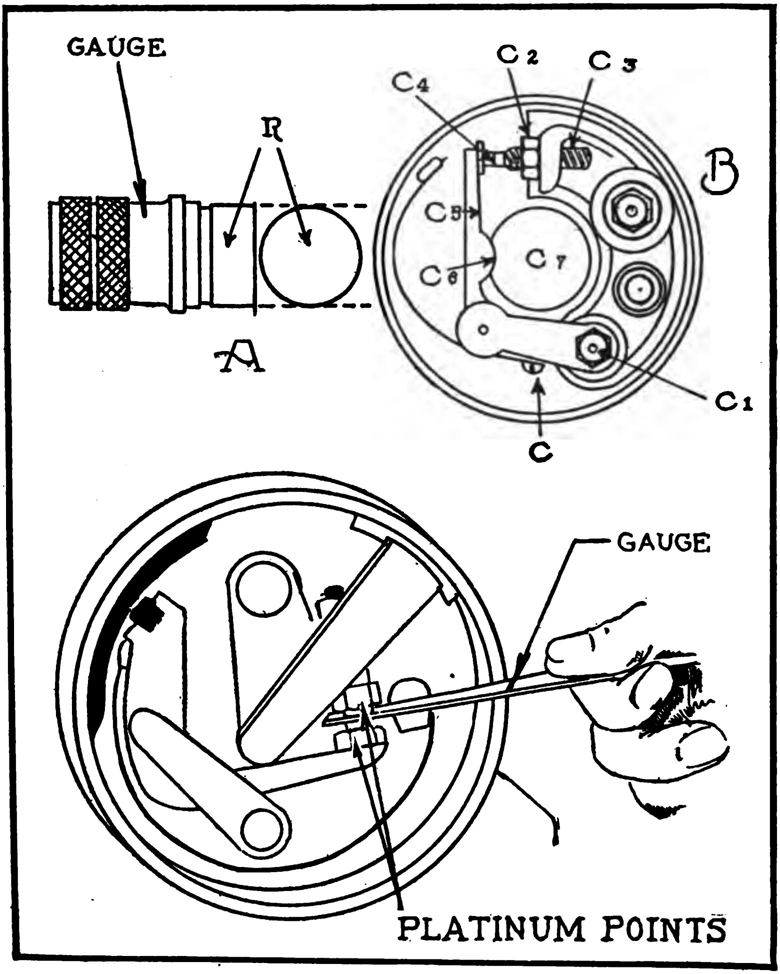


Fig. 126.—Outlining the Use of Gauges for Setting Magneto Contact Breaker Points.

Recharging Weak Magnets.—After a high tension magneto has been in use for a time the magnets lose their strength and it is necessary to recharge them in order to restore the magneto to its full efficiency. When magnets are weak the resulting secondary

spark will also be weak and the motor will not run regularly, no matter how carefully the device is adjusted. If the motor does run without misfiring it will not develop its full power if the magnets are weak. An electro-magnet designed to operate on 110-volt current is shown at Fig. 127, A. The core is of soft iron, 1″ in diameter and 8½″ long. They are drilled at the bottom for a retaining screw, which is intended to keep them in contact with a base plate of steel 4½″ x 9″. Two blocks of steel 1¾″ x 2″ x 4″ are drilled to receive the cores, and have set screws in the side so they can be clamped tightly against the core to form polepieces. A brass tube about 1/16″ thick at the side, having flanges at each end projecting over to hold fiber insulating plates as shown, may be turned to the dimensions indicated in a lathe or may be made up of sheet stock if desired. The hole through the center of the brass spool is of such size as to permit the core to fit freely in its interior. Besides this equipment, 22 lbs. of No. 20 B. & S. gauge insulated copper wire will be needed. Eleven pounds is wound around each brass tube, winding one coil in one direction and the other the opposite way. Leave about 6″ of wire when starting to wind the coil in order to make a connection between them. After both coils have been wound shellac them thoroughly and wind insulating tape over the outside. The cores are then fastened to the iron base plate, the coils are slipped over the cores and the pole pieces attached to keep the coils in place. The view of the completed magnet is clearly shown in the assembly. This can only be used with 110 volts direct current.

Before recharging the generator magnet it is important to test the polarity of the electro-magnet, as the north pole of the magnet to be charged must be brought in contact with the south pole of the electro-magnet and vice versa. It is not difficult to ascertain the polarity by using an ordinary compass or magnetic needle, the marked pole of which will point toward the north. Once the polarity has been determined the poles may be marked in any desired way, usually by stamping the north pole N and the south pole S. Another magnet-charging device, which was described in the Commercial Motor, utilizes storage batteries as a source of magnetizing current. The magnets are composed of soft iron core

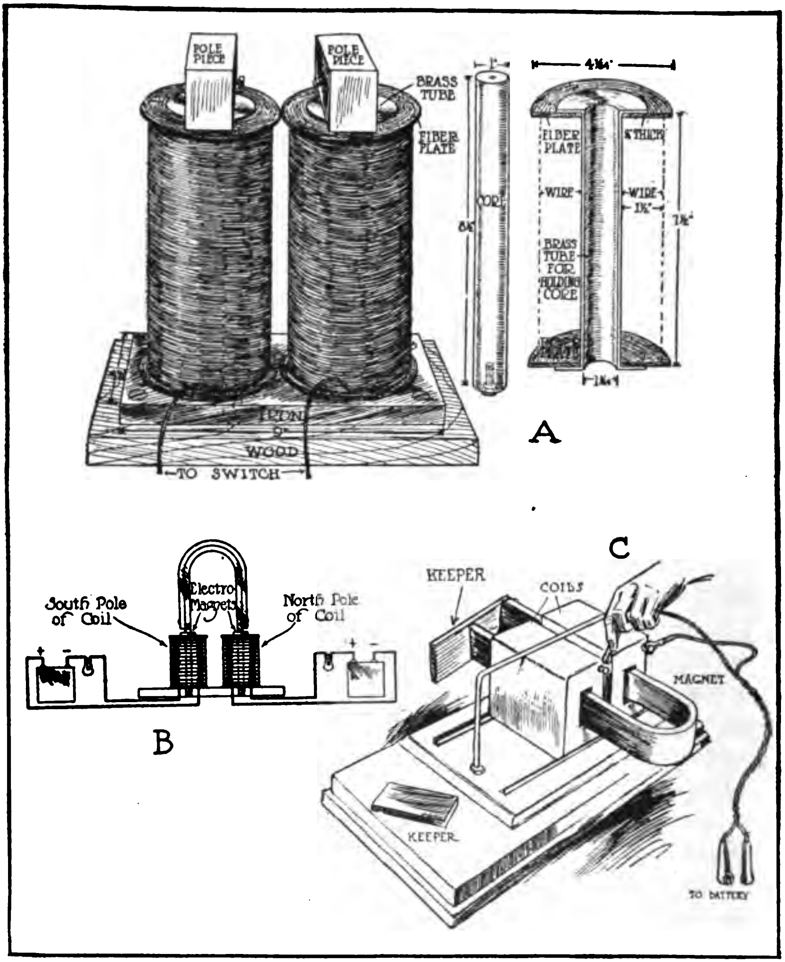


Fig. 127.—Magnet Recharging Devices.

pieces about 6″ long and 1″ in diameter. The base is constructed of mild steel plate, the cores being fastened to the plates by screws or by turning down the end of the core and threading it to fit the hole in the base plate. Before screwing down the core pieces they are wound with No. 22 gauge insulated wire, the ends being left

free. The wires are connected up to a pair of storage batteries, as shown, and the latter are so connected up that the polarity of the soft iron cores are north and south respectively. Enough of the wire is wound on to have coils of about 2″ in diameter. If the core shows signs of overheating, low-voltage lamps should be placed in the circuit to introduce some resistance. The voltage of the lamp to be used depends entirely upon the voltage of the battery used to energize the magnet. It is stated that the magnets will be charged if they are merely placed in contact with the energized cores until they have absorbed sufficient magnetism to enable them to sustain a weight of 20 lbs., after which they are ready to be replaced on the magneto. This is shown at Fig. 127, B.

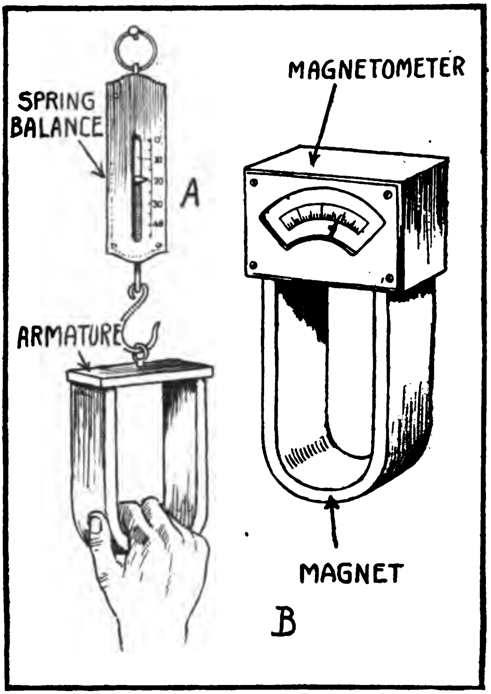


Fig. 128. — Methods of Testing Magnet Strength After Recharging. A—With Spring Balance. B—With Magnetometer.

The illustration at C, Fig. 127, shows the Seanor garage magnet charging outfit, which is claimed to charge the magnet in one minute. From the exterior view of the device it will be evident that it consists of a base upon which are mounted two solenoid coils carried in square boxes. The magnets to be charged are inserted through the center of these coils during the energizing process. In order to accommodate a horseshoe magnet of any spread, one of the coil boxes is mounted so the distance between the

two openings is altered if desired. As ordinarily constructed, the windings are wound for 6 volts and 20 amperes. In charging a magnet the ends of the horseshoe are brought up against an iron core of the coil in such position that the magnet is attracted and not repelled by the core. The magnet is then pushed through the apertures in the centers of the coil boxes, taking the place of the iron core, which is slowly pushed out. The current is then connected for merely the length of time required in touching one of the terminals of the wire to the binding post two or three times. A keeper is then laid across the part of the magnet arch which projects beyond the coil boxes, and with the keeper still in place the magnet is replaced on the magneto. It is stated that a freshly charged Tungsten steel magnet of a large magneto will lift in the neighborhood of 20 lbs. as ordinarily energized by the magneto manufacturer. It is stated that with this device the magnet pull can be increased to 30 lbs., which, of course, means a stronger magnetic field when reassembled on the magneto.

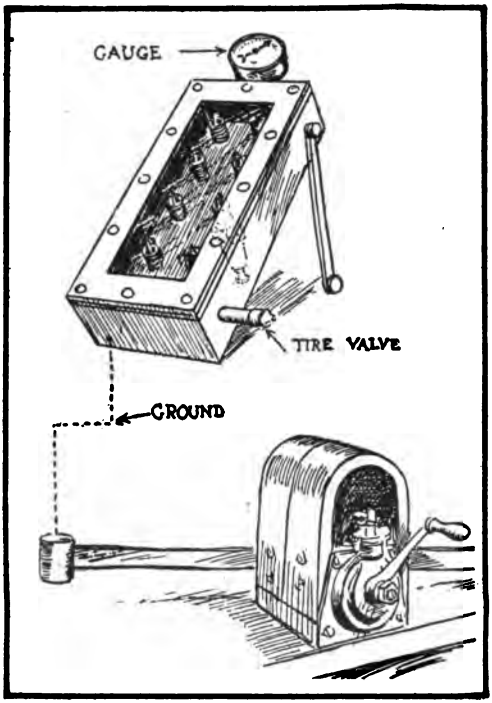


Fig. 129.—How to Test Magneto with Spark Plugs Under Air Pressure.

The strength of a repaired magneto can be easily tested by the simple device shown at Fig. 129. Spark plugs are screwed into an air-tight box with glass cover and air is pumped into the box so that a pressure of 100 pounds is shown on gauge. The spark plugs are

connected to the distributor contacts. The armature is revolved l
any suitable means and sparks should jump the spark plug air gap

Application of Typical Magneto Forms.—The usual meth
of installing a magneto is to place it on a bracket fastened to tl

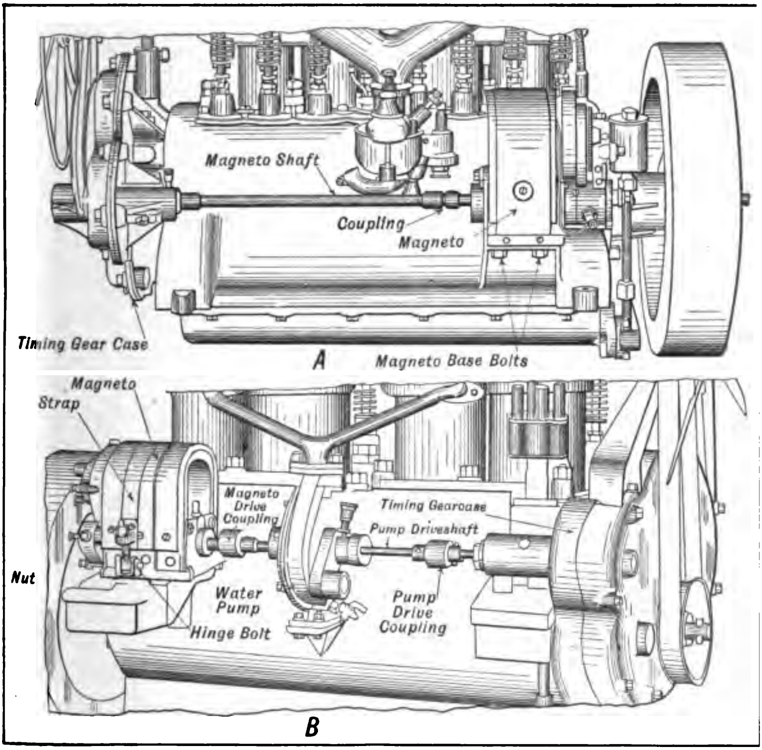


Fig. 130.—Conventional Methods of Placing and Driving Magnetos. A—System Used on Regal Engines. B—Magneto Driven from Pump Shaft Extension.

engine base so the contact breaker and distributor will be hand
for immediate inspection or adjustment. It is desirable to pla
the device on the inlet side of the engine and as far away from tl
exhaust piping as possible, because of the excess heat which exis
at this point is liable to injure the insulation of the winding

Methods of installation which are typical of conventional practice are shown at Fig. 130. At A the magneto is placed on a cast bracket formed integral with the top half of the engine base and is driven from the timing case at the front of the engine by a length of shaft. At B the magneto is also housed at the rear end and is carried on a base plate formed integrally with one of the crank-case supporting arms. The drive is by an extension of the pump shaft, that member being driven by suitable gearing in the cam-shaft timing gear casing.

Gear drive is the best method of driving a magneto armature and direct spur-gear connection is better than either bevel or spiral gear trains because it is the best wearing form of gearing. Silent chains may be used for driving if some form of adjustment is provided to compensate for chain stretch. When a magneto is driven by a shaft, as shown at Fig. 132, A and B, it is customary to provide some sort of a universal joint or Oldham coupling between the armature and the driving member in order that any inaccuracies in alignment of the driving shaft will not stress the ball bearings supporting the armature. It is desirable to protect the instrument from oil or water by placing it in a case of fiber or leather, and in modern types the contact breaker and distributor housings are closed by easily removed and yet practically dust-tight coverings.

Metallic or carbon particles and dirty oil may cause internal short circuiting and it is desirable to have the contact-maker case and the distributor cover arranged in such a way that they may be easily reached for cleaning. Modern magnetos are usually secured in some way that will permit a ready removal. In that shown at A, Fig. 130, a number of through bolts are screwed from the under side of the bracket into the magneto base and it is necessary to remove these before the magneto can be lifted off its support. The method shown at Fig. 130, B, is preferable as the ignition device may be removed from the base by slackening one nut on the hinge bolt which keeps the metallic strap tight, thus holding the magneto in place.

Various other methods of utilizing strap members are shown at Fig. 133. In that shown at A the strap is made in two pieces and is held together at the top by a clamp bolt. The method of securing

a magneto shown at B is practically the same, except that the retention member is a small knob which can be easily turned by the hand. At C the strap encircles the magneto completely and is held in place by a single nut under the bracket. A modification

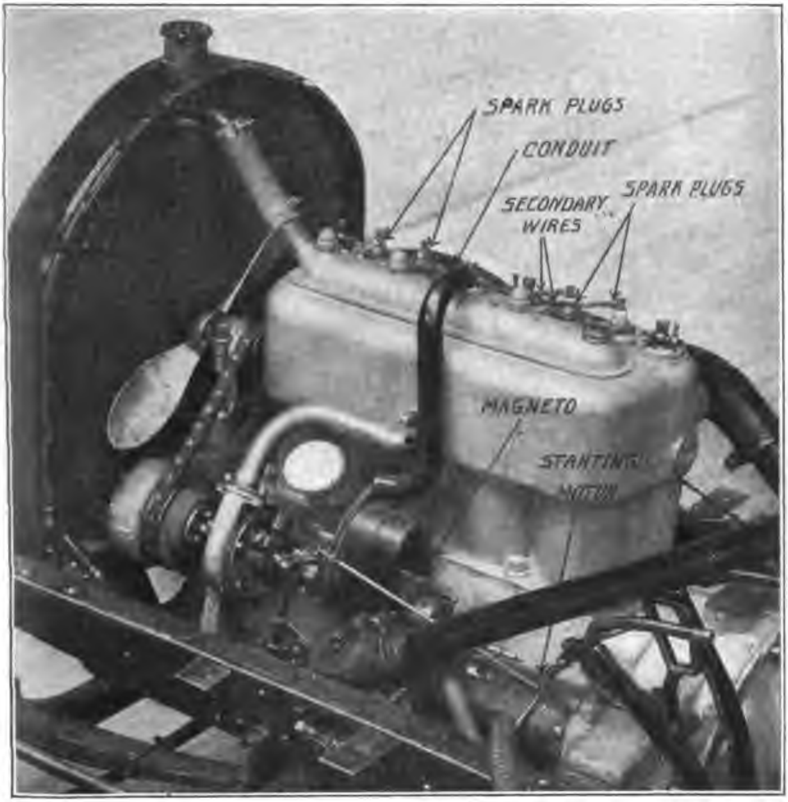


Fig. 131.—Hew Magneto is Installed on 1916 Jeffery Four Power Plant.

of this method is depicted at D. The strap, in this instance, is just bent over the arch of the magnets and held in place by the long swinging bolt which is hinged at the bottom of the magneto.

One of the simplest methods of driving a magneto is that shown at Fig. 17 (Chap. I), which is a bottom view of the Ford engine

case. The stationary coils of the magneto are attached to the crank case, and the revolving magnets rotate with the fly wheel, which in turn is securely attached to the crank shaft. With this form of drive there can be no interruption in current generation and there are no gears, chains, or other connections to wear and produce noise or interfere with generation of current.

When the magneto was first introduced it was looked upon with suspicion by the motoring public. Therefore some designers compromise and furnish two separate systems, one composed of a magneto, the other an auxiliary group comprising a battery, timer and coil, which supply the current to a set of spark plugs distinct from those supplied from the magneto. It was found difficult with some types of magnetos to start the engine directly from magneto current so the battery outfit was depended upon for starting the engine as well as emergency service. The parts of the modern high-tension magneto have been simplified and strengthened and as the various parts may be removed easily and replaced without trouble and special care taken so the adjustments and cleaning necessary may be easily understood by the layman, there is very little liability at the present time of a magneto giving out without warning.

When a magneto is installed some precautions are necessary relating to wiring and also the character of the spark plugs employed. The conductor should be of good quality, have ample insulation and be well protected from accumulations of oil which would tend to decompose rubber insulation. It is customary to protect the wiring by running it through the conduits of fiber or metal tubing lined with insulating material, as shown at Fig. 134. Multiple strand cables should be used for both primary and secondary wiring and the insulation should be of rubber at least $\frac{3}{16}$ inch thick.

The spark plugs commonly used for battery and coil ignition cannot always be employed when a magneto is fitted. The current produced by the mechanical generator has a greater amperage and more heat value than that obtained from transformer coils excited by battery current. The greater heat may burn or fuse the slender points used on some battery plugs and heavier electrodes are needed

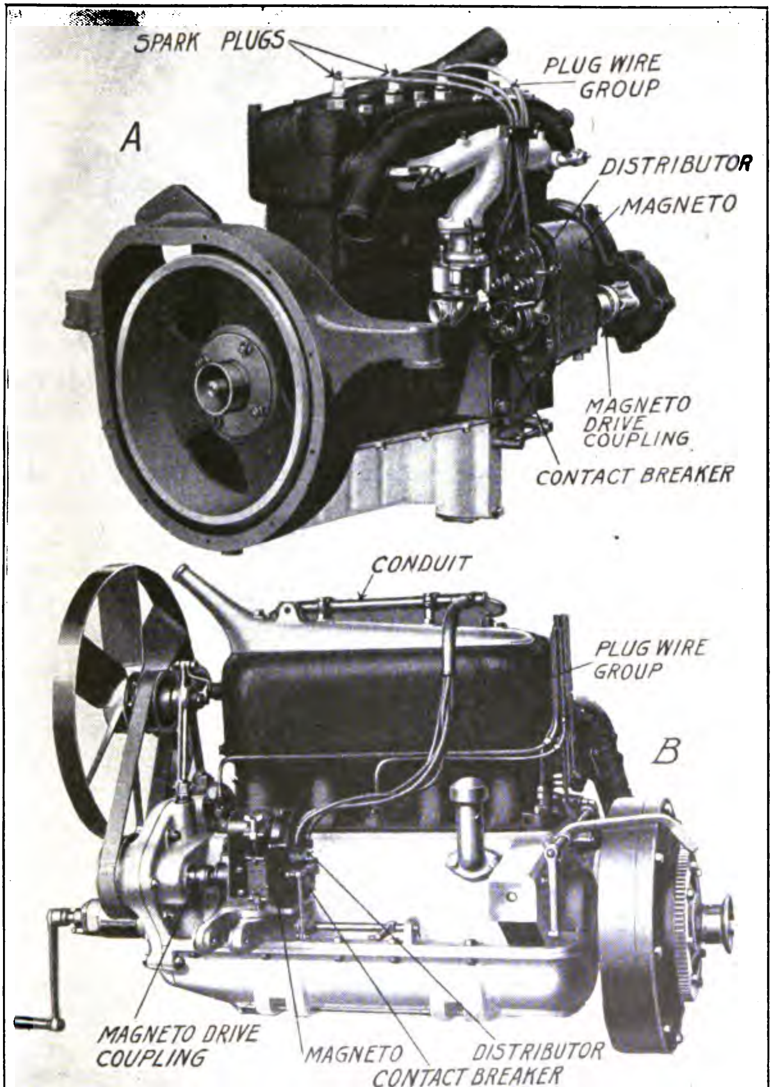


Fig. 132.—Typical Magneto Installations. A—Simms Magneto on Maxwell Motor. B—Bosch D U 4 on White "45" Engine.

to resist the heating effect of the more intense arc. While the current has greater amperage it is not of as high potential or voltage as that commonly produced by the secondary winding of an induction coil, and it cannot overcome as much of a gap. Manufacturers of magneto plugs usually set the spark points about $\frac{1}{64}$ of an inch apart. The most efficient magneto plug has a plurality of points so that when the distance between one set becomes too great the spark will take place between one of the other pairs of electrodes which are not separated by so great an air space.

Timing Magneto Ignition Systems.—An ideal method of magneto placing and one followed by a large number of manufacturers is shown at Fig. 132, B. In this the device is fitted to a four-cylinder engine, and as the armature must be driven at the same speed as the crankshaft, it is necessary to use but one extra gear, that being the same size as the engine shaft pinion and driven by the camshaft speed reduction gear. The sketch, Fig. 135, illustrates the best method of timing the magneto, which is one of the direct high-tension type. The position of the various parts is clearly shown. Having fixed the magneto to the engine crankcase, the driving pinion, or one of the members of a flange or Oldham coupling, is put loosely on the tapered end of the armature shaft, and the cover to the distributor and the dust cover of the contact breaker are removed to allow one to control the position of the armature. The motor is now turned over by hand so the piston in the first cylinder is at top center, which can be determined either by watching the crankshaft through a suitable opening in the engine base, by reading the marks on the flywheel rim, or by inserting a wire through a compression relief petcock or spark plug hole, if either of these is at the top of the cylinder.

The armature of the magneto is then brought to the position indicated in sketch, which represents the fitting of a magneto that is turning clockwise when viewed from the driving end. The distance between the end of the armature and the pole piece should be between 14 and 17 mm or between .5511 inch and .6692 inch. (See Fig. 95.) This represents an advance of about .5 inch on a motor with a five-inch stroke. A graphic chart, prepared by the Bosch Company and reproduced at Fig. 136, shows the relation

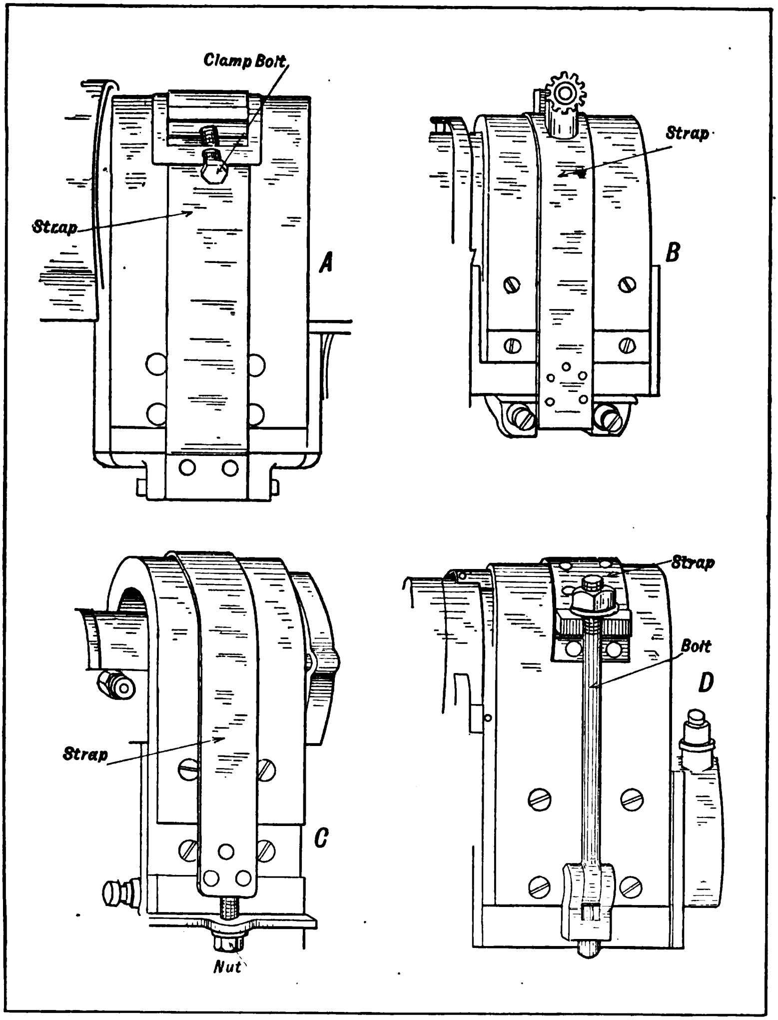


Fig. 133.—Simple Methods of Holding Magnetos in Place on Engine Base to Permit of Easy Removal of Apparatus when Desired.

between piston travel and crankshaft movement for engines of different strokes very clearly. The armature is uncovered by removing the flat casing cover lying between the horseshoe magnets, this often carrying the safety spark gap, and normally serving as a lid. If earlier timing be desired for any special purpose the gap may be widened a trifle, if it be thought the timing is too

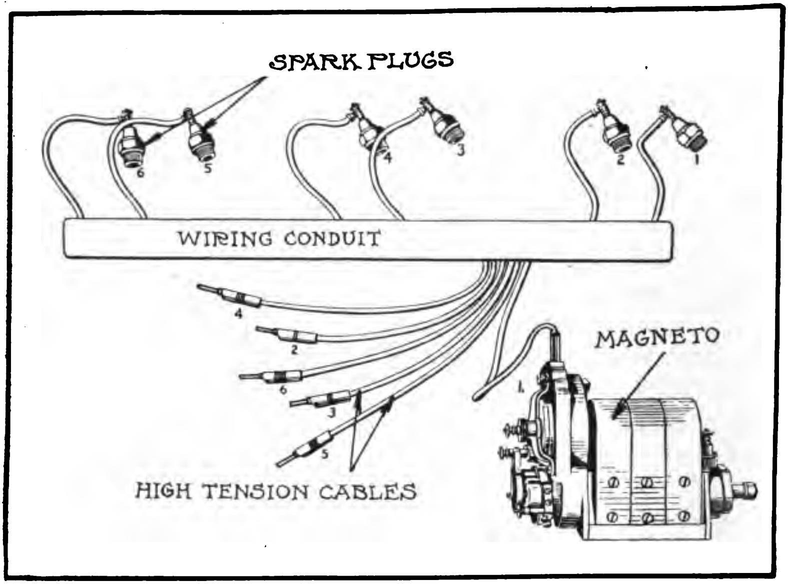


Fig. 134.—How High Tension Magneto Wiring is Carried by an Insusulated Conduit.

far advanced, the gap may be lessened. The contact breaker is fully advanced at this time and the contact points are just about to separate. Having placed everything in position as described, tighten the coupling on the taper shaft and ream out for a small taper pin.

The connections to the various cylinders must be made in the order they fire (see following tabulation). When the cover to the distributor is off, see at which segment the brush is contacting.

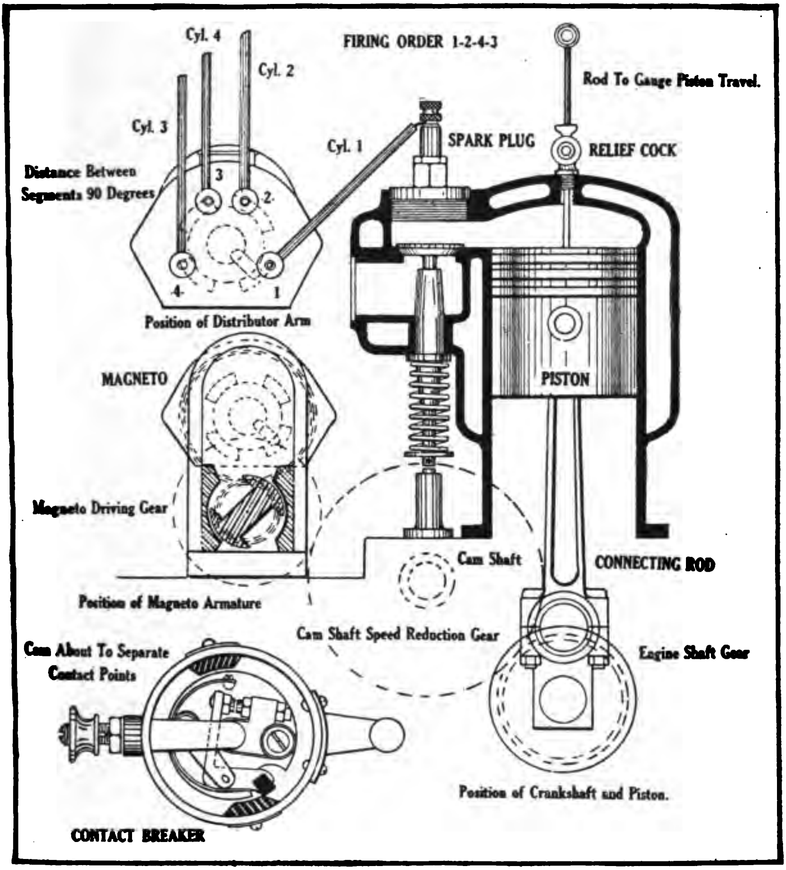


Fig. 135.—Simplified Diagram Explaining Method of Timing Magneto Ignition System.

The wire to the spark plug in the first cylinder is then led to the terminal corresponding to this segment. Then the plug in the cylinder that is next to fire is coupled to the next segment, and so on. The numbers on the distributor show the order in which the various contacts are brought in contact with the rotating distributing brush, and not that in which the cylinders fire. In the sketch the cylinders fire 1-2-4-3. Therefore, the segment num-

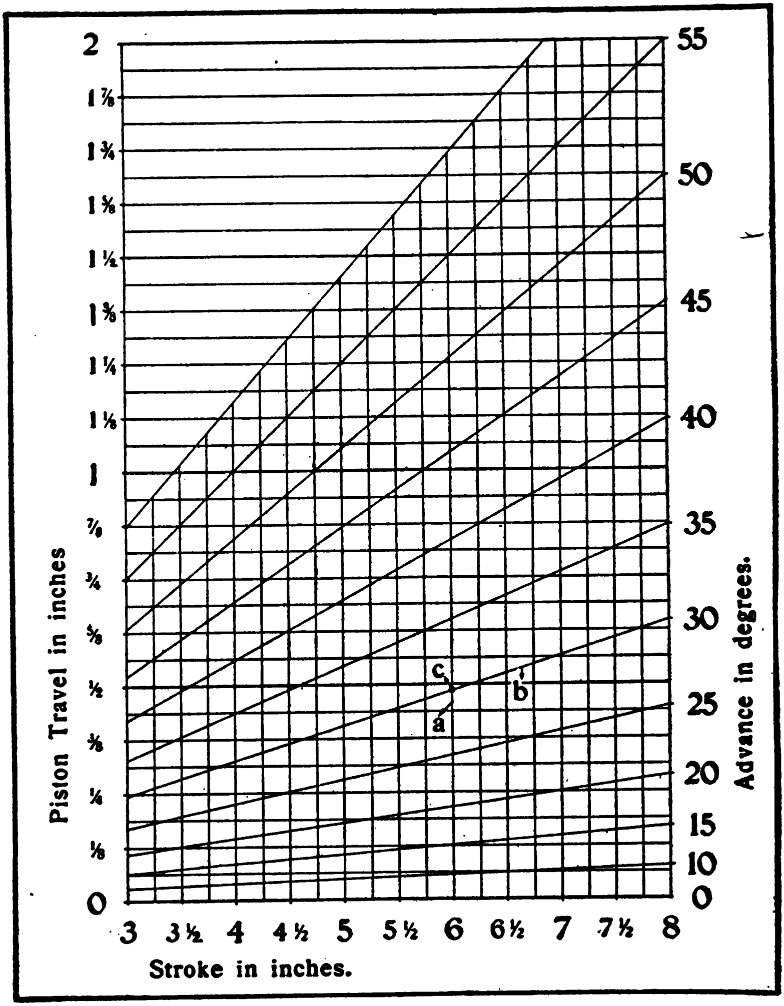
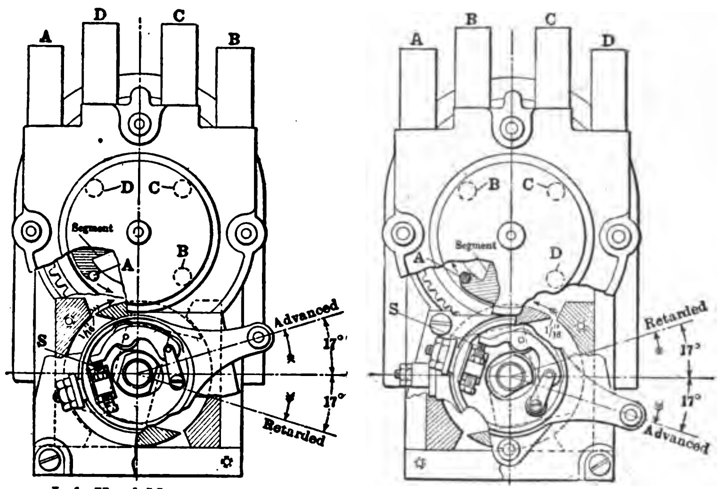


Fig. 136.—Bosch Chart for Determining Advance with Various Piston Strokes.

ber 3 is coupled to the plug in cylinder 4, and the segment 4 is connected to the plug in cylinder 3, which is thus the last to fire if the explosion takes place first in cylinder 1. The direction of

the distributor brush rotation, if driven by the usual form of gearing, is opposite to that of the magneto armature. Obviously, if one cylinder is timed correctly, the remaining members will also fire at the proper time in the cycle of operations. The positions of the armature, distributing brush, contact breaker cam and



Left Hand Magneto.
Looking at Machine from Driving End. Points (S) about to Open as Armature Core leaves Pole Piece about 1/16″, Segment just under Brush.

Right Hand Magneto.
Looking at Machine from Driving End. Points (S) about to Open as Armature Core leaves Pole Piece about 1/16″, Segment just under Brush.

Fig. 137.—Explaining Method of Timing Splitdorf Magneto.

engine piston are easily ascertained by inspection of drawing. The methods of timing Splitdorf magnetos are shown at Fig. 137.

Firing Order of Typical Engines.—The following information relative to timing of leading 1914 and 1915 models of American manufacture will prove of great value to the repairman called upon to repair many different makes of cars. It is well to remember, if the firing order is not known, that it can be easily determined by following the inlet valve movements in the cylinders and noting the order of opening of these members.

ABBOTT-DETROIT.

34–40 AND 44–50—FIRING ORDER 1–3–4–2.

BELLE ISLE—FIRING ORDER 1–5–3–6–2–4.

Magneto Setting—Piston dead centre, lever fully retarded. Full advance. spark occurs with crankshaft 13 degrees ahead of dead centre. Contact point gap .018 inch.

ALLEN.

40—FIRING ORDER 1–2–4–3.

Magneto Setting—Piston top dead centre, lever fully retarded.

AMERICAN.

SCOUT—FIRING ORDER 1–3–4–2.

644, 646 AND 666—FIRING ORDER 1–5–3–6–2–4.

Magneto Setting—Three-quarter inch after dead centre on flywheel.

ARBENZ.

FIRING ORDER 1–3–4–2.

Magneto Setting—Piston .03125 inch late, lever fully retarded.

AUBURN.

4–40 AND 4–41—FIRING ORDER 1–3–4–2.

Magneto Setting—Piston .03125 inch late, lever fully retarded.

6–46 AND 6–45—FIRING ORDER 1–4–2–6–3–5.

Magneto Setting—Piston top dead centre, lever fully retarded.

BUICK.

B 24. 25, 36, 37 AND 38—FIRING ORDER 1–3–4–2.

Delco—With timer cam fully retarded, spark occurs 40 degrees past upper dead centre on firing stroke. With hand spark lever half-way advanced, spark occurs at approximately top dead centre.

B 55—FIRING ORDER 1–4–2–6–3–5.

Delco—Piston dead centre with timer fully retarded.

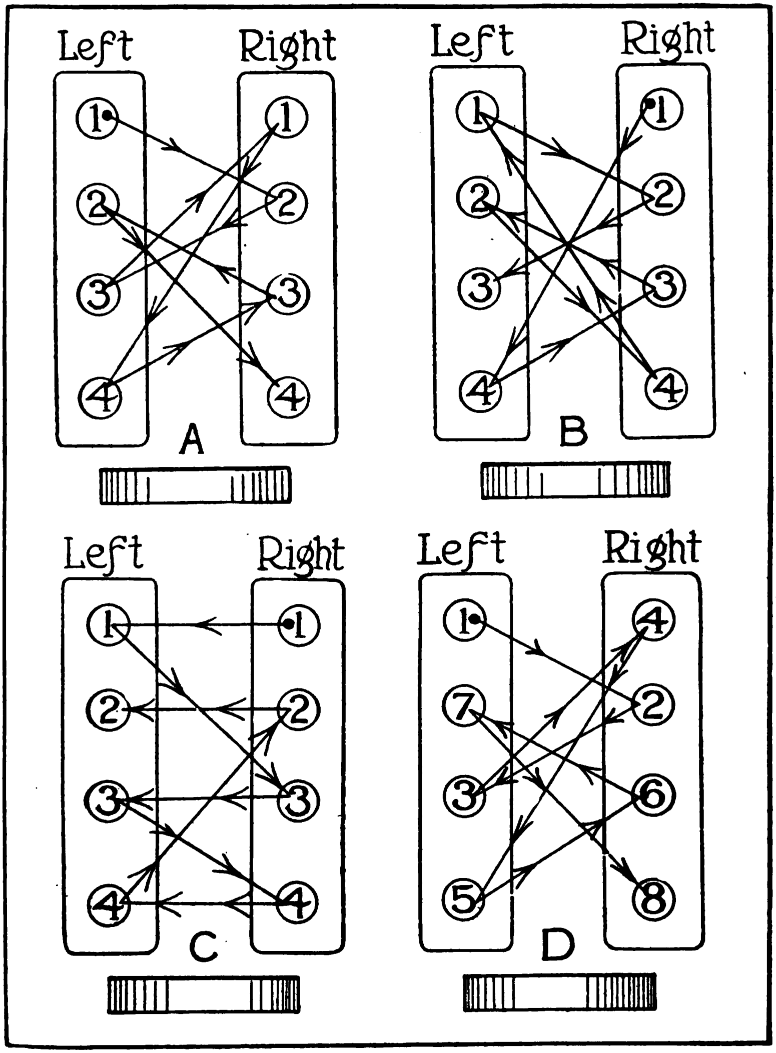


Fig. 138.—Typical Firing Orders of Eight Cylinder V Engine.

CASE.

25 R AND 35 S—FIRING ORDER 1–3–4–2.

Magneto Setting—One thirty-second inch before top dead centre.

40 O—FIRING ORDER 1–3–4–2.

Magneto Setting—One-sixteenth inch after top dead centre.

CHALMERS.

24—FIRING ORDER 1–4–2–6–3–5.

Magneto Setting—One and one-half inches past centre, lever fully retarded.

CHANDLER.

SIX—FIRING ORDER 1–5–3–6–2–4.

Magneto Setting—Piston dead centre, lever fully retarded.

COLE.

FOUR—FIRING ORDER 1–3–4–2.
SIX—FIRING ORDER 1–5–3–6–2–4.

Delco—Piston dead centre, distributor fully retarded.

CONTINENTAL.

27—FIRING ORDER 1–3–4–2.

Magneto Setting—Three-quarter inch after dead centre on flywheel.

GLIDE.

36 AND 30—FIRING ORDER 1–3–4–2.

Westinghouse—Piston top dead centre.

GRANT.

M—FIRING ORDER 1–3–4–2.

Magneto Setting—Lever fully advanced, piston .3125 inch before top dead centre.

HAYNES.

28—FIRING ORDER 1–3–4–2.

Magneto Setting—One sixty-fourth inch advanced on down stroke.

26 AND 27—FIRING ORDER 1–4–2–6–3–5.

Magneto Setting—One sixty-fourth inch advanced on down stroke.

HUDSON.

6-40 AND 6-54—FIRING ORDER 1-5-3-6-2-4.

HUPMOBILE.

32—FIRING ORDER 1-2-4-3.

Magneto Setting—Piston dead centre, lever fully retarded.

IMPERIAL.

34 F B, 32 AND 34 4 M—FIRING ORDER 1-2-4-3.
54 AND 44-6—FIRING ORDER 1-5-3-6-2-4.

Magneto Setting—Points break with piston on dead centre.

INTER-STATE.

45—FIRING ORDER 1-5-3-6-2-4.

JACKSON.

MAJESTIC AND OLYMPIC—FIRING ORDER 1-3-4-2.

Magneto Setting—Piston .125 inch before top centre.

SULTANIC—FIRING ORDER 1-5-3-6-2-4.

Magneto Setting—Piston .125 inch before top centre.

JEFFERY.

93—FIRING ORDER 1-3-4-2.
96—FIRING ORDER 1-4-2-6-3-5.

Magneto Setting—Piston dead centre, lever fully retarded.

KEETON.

F—FIRING ORDER 1-5-3-6-2-4.

Magneto Setting—Points break 6.5 degrees before centre.

KING.

B—FIRING ORDER 1-3-4-2.

Magneto Setting—Points break with lever fully retarded from centre to .5 inch past on flywheel.

KNOX.

44 AND 45—FIRING ORDER 1-3-4-2.

Magneto Setting—Piston .75 inch before top centre, lever fully retarded. Battery, piston .375 inch before top centre.

KRIT.

L—Firing Order 1–3–4–2.

Magneto Setting—Piston .125 inch before top dead centre, lever fully retarded.

LEWIS.

Six—Firing Order 1–5–3–6–2–4.

Magneto Setting—Piston top dead centre, lever fully retarded. Full advance equals .234375 inch of piston stroke.

LOCOMOBILE.

48 LD and RD, 38 RD and LD—Firing Order 1–5–3–6–2–4.

Magneto Setting—Three-eighths to .4375 inch before top dead centre, lever fully advanced.

LOZIER.

Four—Firing Order 1–3–4–2.

77—Firing Order 1–4–2–6–3–5.

Magneto Setting—Piston dead centre, lever fully retarded.

LYONS-KNIGHT.

K4—Firing Order 1–3–4–2.

Magneto has six-inch range on 20-inch flywheel from one inch past centre to five inches before.

MAXWELL.

25–4 and 35–4—Firing Order 1–3–4–2.

50–6—Firing Order 1–4–2–6–3–5.

Magneto Setting—Points break with piston on dead centre, lever fully retarded.

MOLINE-KNIGHT.

26–50—Firing Order 1–3–4–2.

Magneto Setting—Piston top dead centre.

MOON.

42—Firing Order—1–3–4–2.

6–50—Firing Order 1–5–3–6–2–4.

Delco—Spark breaks on centre in retarded position.

NATIONAL.

40—Firing Order 1–3–4–2.

Magneto Setting—Piston .0625 inch past top dead centre, lever fully retarded.

Six—Firing Order 1–5–3–6–2–4.

Magneto Setting—Piston .125 inch before top dead centre, lever fully retarded.

NORWALK.

C and D—Firing Order 1–4–2–6–3–5.

Atwater Kent—Piston is .093 inch past centre with distributor set at retard.

OLDSMOBILE.

54—Firing Order 1–5–3–6–2–4.

Delco—Spark occurs at piston dead centre with hand spark lever fully retarded or .390625 before dead centre with lever fully advanced.

OVERLAND.

79—Firing Order 1–3–4–2.

Magneto Setting—One and one-quarter inches after dead centre (flywheel), lever fully retarded.

PACKARD.

2–38—Firing Order 1–4–2–6–3–5.

Magneto Setting—Piston .5 inch before top centre, lever fully advanced.

PAIGE.

25 and 36—Firing Order 1–3–4–2.

Magneto Setting—Place No. 4 piston on top dead centre (Compression stroke). Points should just begin to break.

PIERCE-ARROW.

Sixes—Firing Order 1–5–3–6–2–4.

Magneto Setting—Magneto mark on flywheel should be 4.8125 inches ahead of 1 and 6 top centre and 1 showing in timing window. Piston is .5 inch before top dead centre of 33 degrees of crank circle. Battery spark occurs with piston 2.125 inches before top dead centre or 75 degrees of crank circle with spark lever fully advanced.

PILOT.

50—Firing Order 1–3–4–2.
60—Firing Order 1–5–3–6–2–4.

Magneto Setting—Points break with lever fully retarded and piston on dead centre.

POPE-HARTFORD.

35—Firing Order 1–2–4–3.

Magneto Setting—Piston top dead centre. Maximum advance of magneto .5 inch on piston travel.

PREMIER.

6–48 and Weidely—Firing Order 1–4–2–6–3–5.

Magneto Setting—Piston dead centre, lever fully retarded.

REGAL.

C, T, N and NC—Firing Order 1–2–4–3.

Magneto Setting—Piston top dead centre, lever fully retarded.

REO.

Fifth—Firing Order 1–3–4–2.

Remy System—Piston top dead centre when indexing button on distributor engages.

SAXON.

A—Firing Order 1–3–4–2.

Atwater Kent—Piston dead centre, distributor fully retarded.

SIMPLEX.

38 and 50—Firing Order 1–3–4–2.

Magneto Setting—Piston .015625 inch before top dead centre.

75—Firing Order 1–3–4–2.

Magneto Setting—Piston dead centre or slightly after.

SPEEDWELL.

H—Firing Order 1–5–3–6–2–4.

Magneto Setting—Points break with piston at top dead centre.

Rotary—Firing Order 1–5–3–6–2–4.

Magneto Setting—One-sixteenth inch after top dead centre, lever fully retarded.

STEARNS-KNIGHT.

FOUR—FIRING ORDER 1–2–4–3.
SIX—FIRING ORDER 1–5–3–6–2–4.

Magneto Setting—Piston top dead centre, points breaking.

STEVENS-DURYEA.

C 6—FIRING ORDER 1–4–2–6–3–5.

Magneto Setting—Figure 1 showing in timing window, 25 degrees before top dead centre (flywheel).

STUDEBAKER.

FOUR—FIRING ORDER 1–3–4–2.
SIX—FIRING ORDER 1–5–3–6–2–4.

Remy System—Spark occurs .75 inch after top dead centre.

VELIE.

5 AND 9—FIRING ORDER 1–3–4–2.
10—FIRING ORDER 1–5–3–6–2–4.

Magneto Setting—Piston top dead centre.

WINTON.

SIX—FIRING ORDER 1–5–3–6–2–4.

Magneto Setting—Piston .125 inch after top dead centre, lever fully retarded and points breaking.

CHAPTER IV

ELEMENTARY ELECTRIC STARTER PRINCIPLES

Types of Self-Starters Defined—One Unit Systems—Two Unit Systems—Three Unit Systems—Parts of Systems and Functions—Generator Types—Current Regulating Means—Methods of Cranking Engine—Starting Switches—Indicators—Roller Clutches—Miscellaneous Devices.

ELECTRIC lighting, cranking and ignition systems for motor cars are of such recent development that it is not possible to describe all systems used for this purpose. Not only do the individual systems vary in detail, but the components of the same system are often of different construction when used on cars of different makes. The standard equipment must include three important functions, namely, the generator which is driven by the engine end which produces electric current to keep a storage battery charged, and the starting motor which is in mechanical connection with the engine and in electrical connection with the storage battery when it is desired to turn the engine over for starting. If the motor and generator are combined in one instrument the starting system is known as a one unit type. If the motor is one appliance and the generator another, the system is said to be a two unit system. Each of these has advantages, and both forms have demonstrated that they are thoroughly practical. In addition to the three main items enumerated, various accessories, such as switches, ammeters, connectors, wiring, protective circuit breakers, automatic current regulators, etc., are necessary for the convenient distribution and control of the electric current. The arrangement of the parts of a typical one unit system in which the motor-generator is used only for starting and lighting is shown at Fig. 139. This shows the location of the various parts in their relation to the other components of the motor car. The motor

generator is mounted at the side of the engine, and is driven by the magneto drive shaft as at A, Fig. 140, when used as a generator, and serves to drive the engine through this means when it is used as a motor. The ignition current is supplied from an independent source, a high tension magneto. The starting switch and that controlling the lighting system are placed on the dash, while the storage battery is carried under the floor of the tonneau. This system, which is known as the Entz, will be described more in detail in following chapter. Latest practice is to use the direct silent chain drive as at Fig. 140, B.

The elements of a one unit system are shown in diagram form at the left of Fig. 141. It will be observed that the armature car-

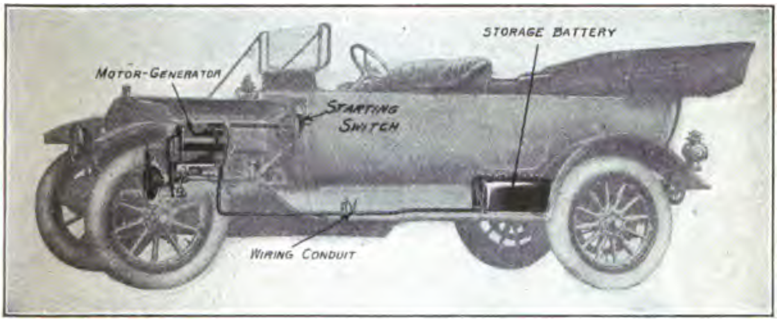


Fig. 139.—Phantom View of Automobile Touring Car Showing Location of Parts of One Unit Starting and Lighting System.

ries two commutators, one of which is used when the armature is driven by the engine and when the device serves as a current generator, the other being employed when the operating conditions are reversed and the electrical machine is acting as a motor to turn over the engine crankshaft. When the device is driven as a generator the small sliding pinion on the short end of the shaft is out of engagement with the spur gear cut on the flywheel exterior. When it is desired to start the engine the spur gear is meshed with the member cut on the flywheel and the current from the storage battery is directed to the windings of the electric machine which becomes a motor and which turns over the engine

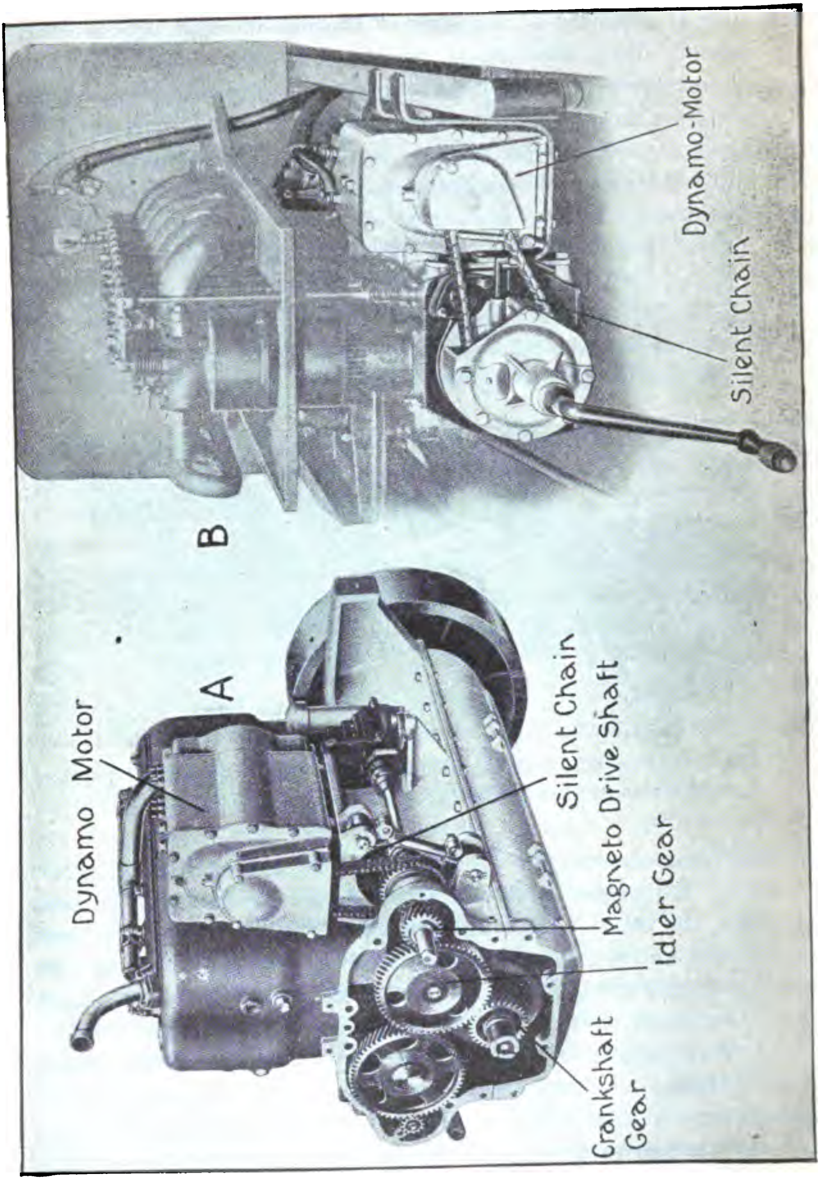


Fig. 140.—Practical Application of One Unit Starting System to Motors of Conventional Design.

crankshaft. When the device is working as a generator the current that is developed goes to the storage battery, and from that member to the various current consuming units.

Sometimes the motor and generator are combined in one casing and the system so provided is erroneously called a "one unit" system. This construction is shown at the right of Fig. 141. In reality such a system is a two unit system, because the electrical machines are uni-functional instead of performing a dual function as does the combined-motor-generator at the right of the illus-

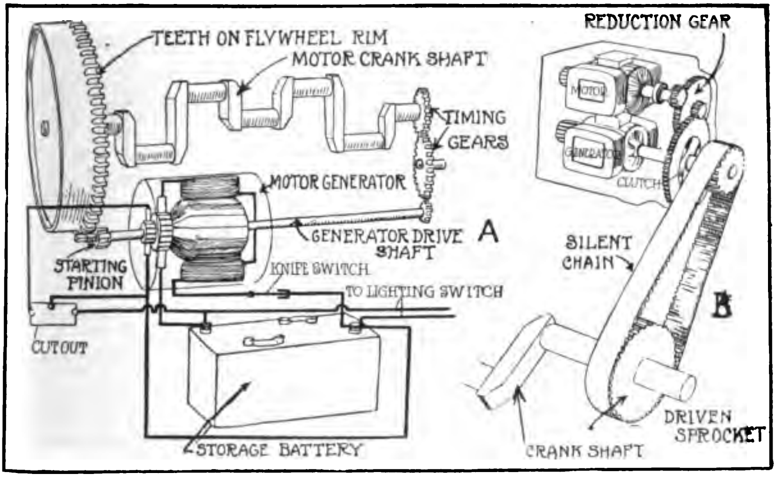


Fig. 141.—Simplified Diagram Showing Operation of One Unit System at A and Two Armature One Unit System at B.

tration. The wiring of the one unit system is shown in simplified form and should be easily followed by any repairman. The parts of a two unit starting and lighting system are shown at Fig. 142. This system is sometimes called a "three unit" system, on account of having a source of independent current supply for ignition purposes. This is shown as fitted to the Overland six-cylinder engine at Fig. 143. As will be observed, the generator in the diagram is driven from the motor crankshaft by silent chain connections, one of the terminals passing through the cut-out device

and to the storage battery, the other terminal running directly to the storage battery terminal having a short by-pass or shunt wire attached to the cut-out. All the time that the engine is running the generator is delivering electricity to the storage battery.

It will be seen that the storage battery is also coupled to the lighting circuits which are shown in a group at the right of the illustration, and to the electric starting motor as indicated. One of the storage battery terminals is joined directly to the switch

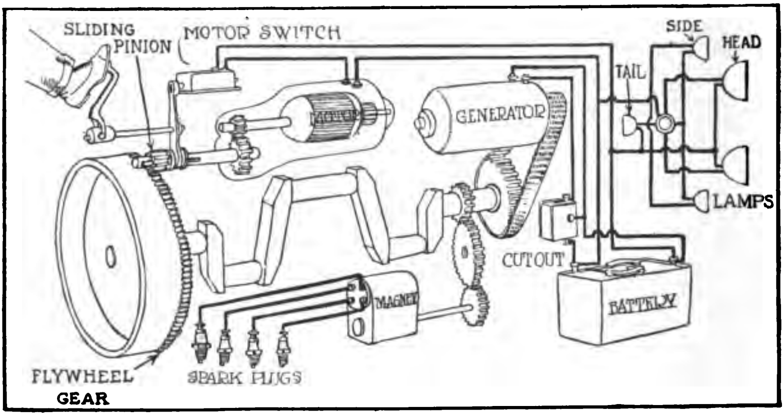


Fig. 142.—Simplified Diagram to Show Arrangement of Parts of Two Unit Starting and Lighting System with High Tension Magneto for Ignition Purposes.

terminal by a suitable conductor, the other goes to one of the terminals on the starting motor, while the remaining terminal of the starting motor goes to the switch. In this system, when the small sliding pinion is meshed with the flywheel gear, the switch is thrown on simultaneously, and the current that flows from the storage battery through the windings of the starting motor rotates the engine crankshaft by means of reduction gears shown. As soon as the engine starts the foot is released and a spring pulls the switch out of contact, and also disengages the sliding pinion from the flywheel gear.

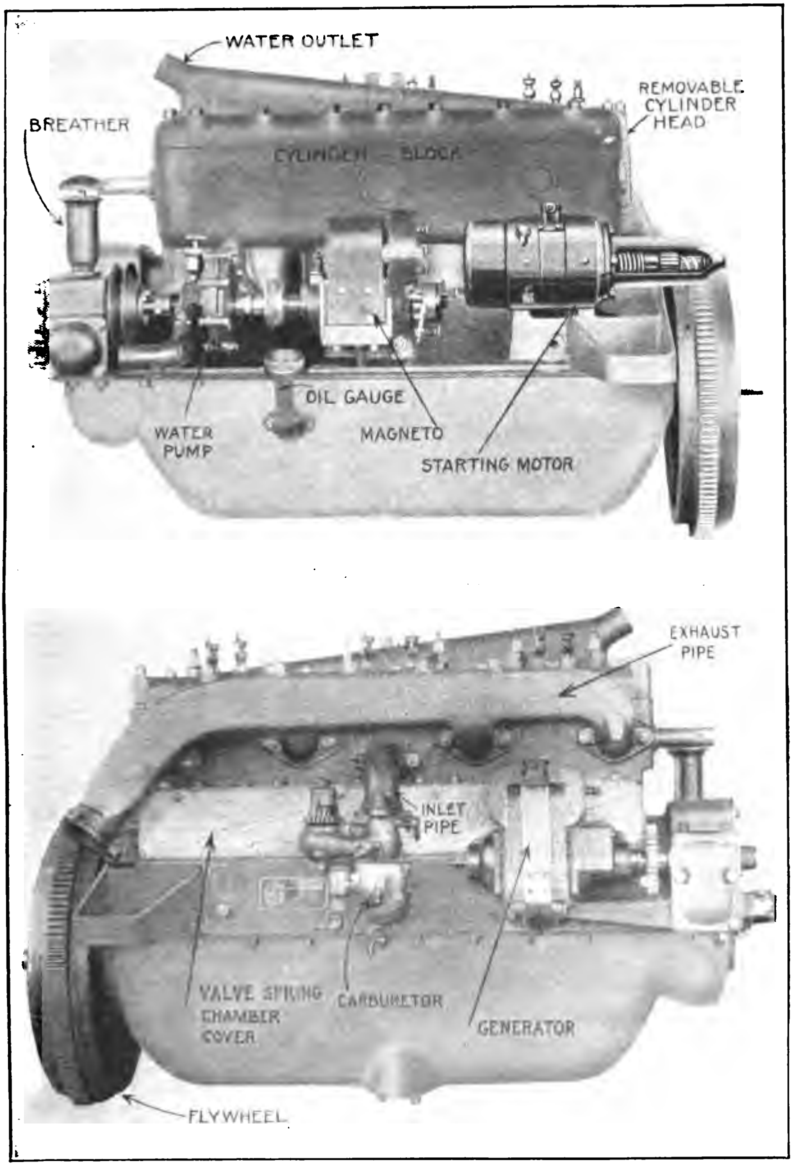


Fig. 143.—Illustration Showing Location of Starting, Lighting and Ignition Units on the Overland Six Cylinder Engine.

The actual appearance of a motor fitted with a two unit motor starting ignition and lighting system is shown at Fig. 144. It will be observed that the generator is driven from the pumpshaft extension by a leather universal joint, while the starting motor is mounted at the back end of the crankshaft in such a position that the automatic sliding pinion may be brought into engagement with

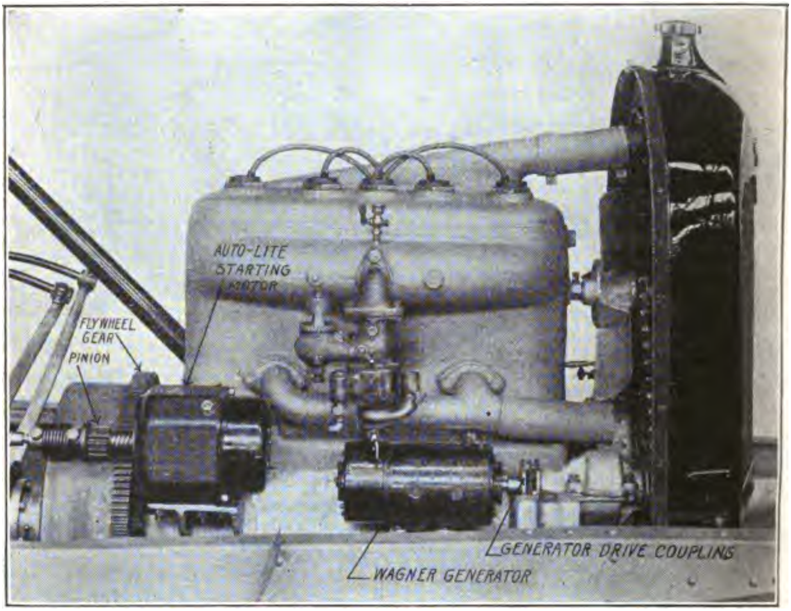


Fig. 144.—Moline-Knight Power Plant Showing Application of Starting Motor with Automatic Pinion Shift and Method of Driving Generator.

the flywheel driving gear. Electrical starting systems are usually operated on either six- or twelve-volt current, the former being generally favored because the six-volt lamps use heavier filaments than those of high voltage, and are not so likely to break, due to vibration. It is also easier to install a six-volt battery, as this is the standard voltage that has been used for several years for ignition and electric lighting purposes before the starting motors were applied.

In referring to a system as a one unit system of lighting, starting and ignition, one means that all of these functions are incorporated in one device, as in the Delco system. If one unit is used for generating the lighting and starting current, and also is reversible to act as a motor, but a separate ignition means is provided such as a high tension magneto, the system is called a "two unit" system. The same designation applies to a system when the current generating and ignition functions are performed by one appliance, and where a separate starting motor is used. The three unit system is that in which a magneto is employed for ignition, a generator for supplying the lighting and starting current, and a motor for turning over the engine crankshaft. Before describing the individual systems it would be well to review briefly the various components common to all systems.

The generator, as is apparent from its name, is utilized for producing current. This is usually a miniature dynamo patterned largely after those that have received wide application for generating current for electric lighting of our homes and factories. The generators of the different systems vary in construction. Some have a permanent magnetic field, while others have an excited field. In the former case permanent horseshoe magnets are used as in a magneto. In the other construction the field magnets, as well as the armature, are wound with coils of wire. In all cases the dynamo or generator should be mechanically driven from the engine crankshaft either by means of a direct drive, by silent chain, or through the medium of the timing or magneto operating gears. Belts are apt to slip and are not reliable.

All the current produced by the generator and not utilized by the various current consuming units such as the lamps, ignition system, electric horn, etc., is accumulated or stored in the storage battery, and kept in reserve for starting or lighting when the engine is not running or for lighting and ignition when the car is being run at such low speed that the generator is not supplying current. Storage batteries used in starting systems must be of special design in order to stand the high discharge and to perform efficiently under the severe vibration and operating conditions incidental to automobile service. The storage battery may be in-

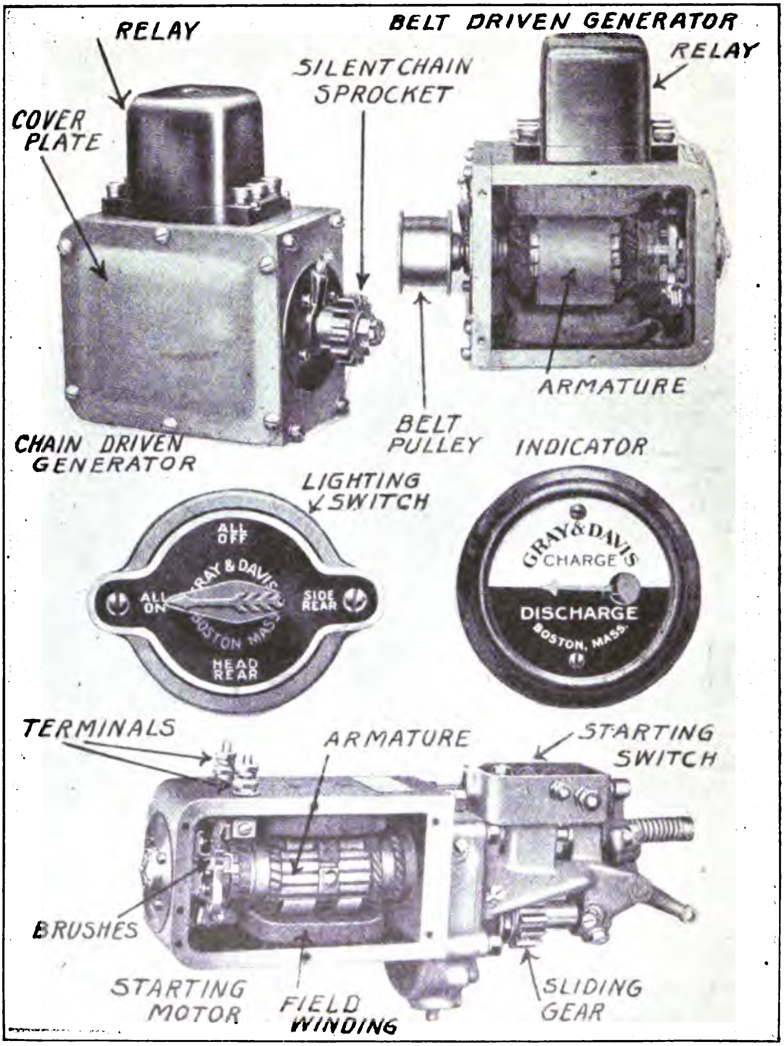


Fig. 145.—Principal Components of Gray & Davis Two Unit Starting and Lighting System.

stalled on the running board of the automobile, under the body, or under the front or rear seat, the location depending upon the design of the car and the degree of accessibility desired. The best practice is to set the storage battery in a substantial carrying case held by rigid braces attached to the frame side and cross members. If the battery should be set under the tonneau floor boards, a door must be provided in these to give ready access to the battery.

The starting motor, which takes the place of the common hand crank, is operated by current from the storage battery, and the high speed armature rotation is reduced to the proper cranking speed by reduction gears of the different forms to be described in proper sequence. The construction of the starting motor is practically the same as that of the dynamo, and it operates on the same principle, except that one instrument is a reversal of the other.

In order to secure automatic operation of a lighting and starting system several mechanical and electrical controls are needed, these including the circuit breaker, the governor, which may be either mechanical or electrical, and the operating switches. The circuit breaker is a device to retain current in the storage battery under such conditions that the battery current is stronger than that delivered from the generator. If no circuit breaker was provided the storage battery could discharge back through the generator winding. The circuit breaker is sometimes called a "cutout." The circuit breaker is usually operated by an electro magnet, and may be located either on the generator itself or any other convenient place on the car, though in many cases the circuit breakers are usually mounted on the back of the dashboard. This device is absolutely automatic in action and requires but little attention.

The governors are intended to prevent an excessive output of current from the generator when the engine runs at extremely high speed. Two types are used: one mechanical, operated by centrifugal force as at Fig. 146, and the other electrical as depicted at Fig. 148. The former is usually a friction drive mechanism mounted in the generator shaft which automatically limits the speed of the dynamo armature to a definite predetermined number of revolutions per minute. The maximum current output is thus

held to the required amount independently of the speed at which the car is being driven. The use of this device minimizes the possibility of overheating the generator or overcharging the battery

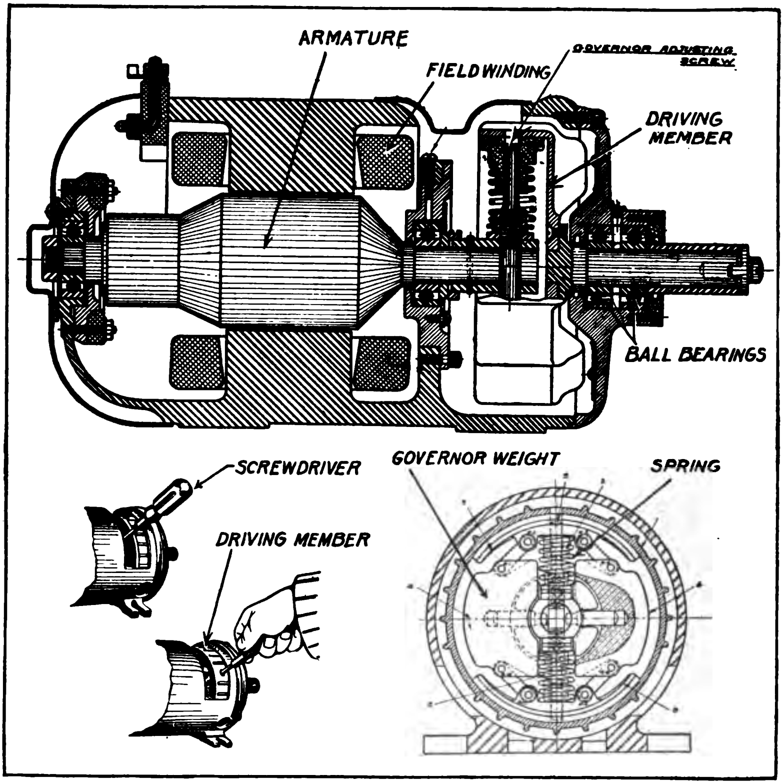


Fig. 146.—Sectional View of Latest Pattern, Gray & Davis Governed Dynamo, Showing Construction of Governor and Method of Adjusting.

at high car speeds. The electrical system of governing does not affect the speed of the armature, but controls the output of the generator by means of armature reaction, a reversed series field winding or weakening the magnetic field in some way when the engine speed is excessive. The governors usually permit a maxi-

mum generator output of from ten to twelve amperes, though the normal charging current is less than this figure.

The Westinghouse generators for example, with inherent regulation have a compound field winding. The battery charging current passes through the series winding in such direction that any increase in the battery charging current tends to reduce the voltage generated, so that the battery is never charged at an excessive rate. When the lights are burning, however, current flows through this series, winding in the reverse direction, increasing the output

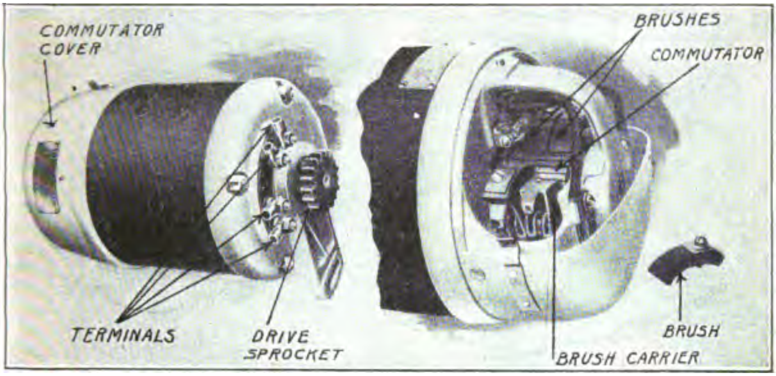


Fig. 147.—The North East One Unit Motor-Generator. View at Right Shows Commutator Cover Removed to Expose Brushes.

of the generator and causing it to assist the battery in carrying the load. With the usual lamp equipment, this increase in generator output is sufficient to operate the lamps without any demand on the battery at ordinary running speeds. At low speeds the battery supplies a certain proportion of the lighting current, and when the engine is not running, the battery supplies the entire demand. This type of generator is shown at the left of Fig. 149 and at the bottom of Fig. 150.

The generators with automatic potential regulators maintain constant voltage regardless of whether the battery is connected to the system or not. The characteristics are such that the battery-charging current tapers off as the battery charge increases, being

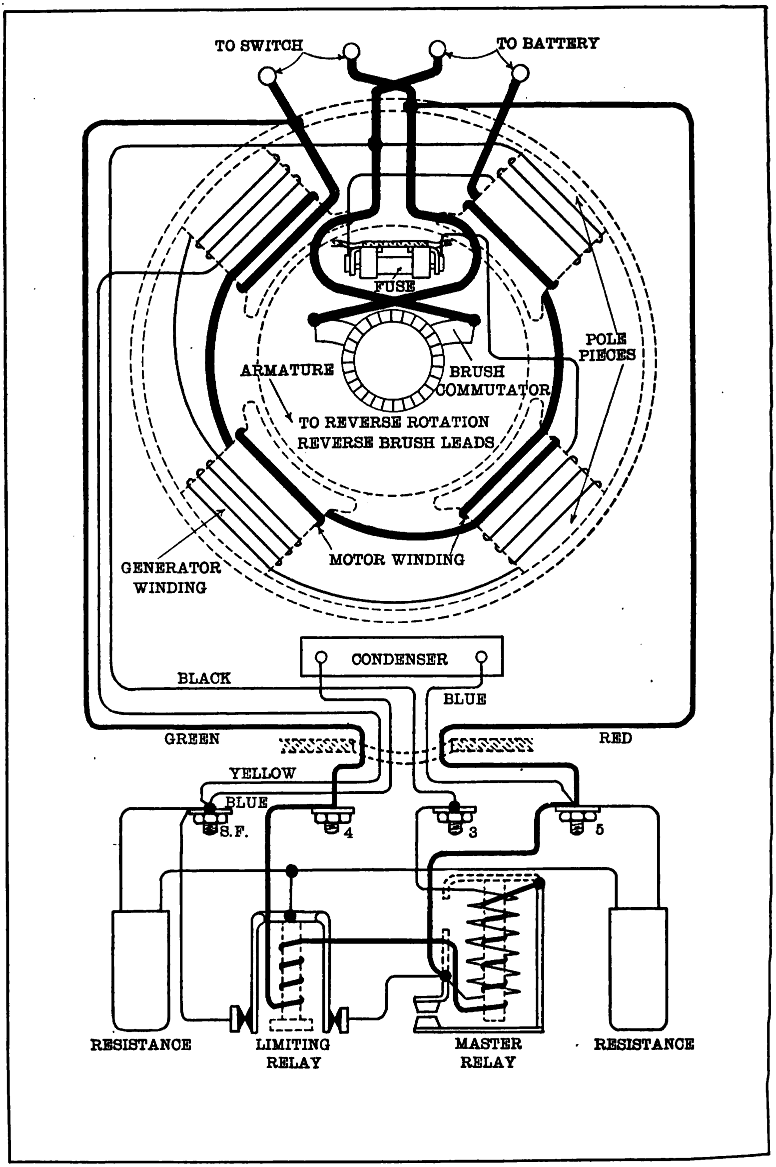


Fig. 148.—Internal Wiring of the North East Motor Generator.

very large when the battery is in a discharged condition and of low value when the battery is fully charged. The voltage is independent of the speed and the amount of lighting load. The regulator consists of a vibrating armature that intermittently short-circuits a high resistance in series with the shunt field winding of the generator, the length of the short-circuit period depending on the load on the generator. A machine working on this principle is shown at the top of Fig. 150 partially dismantled and

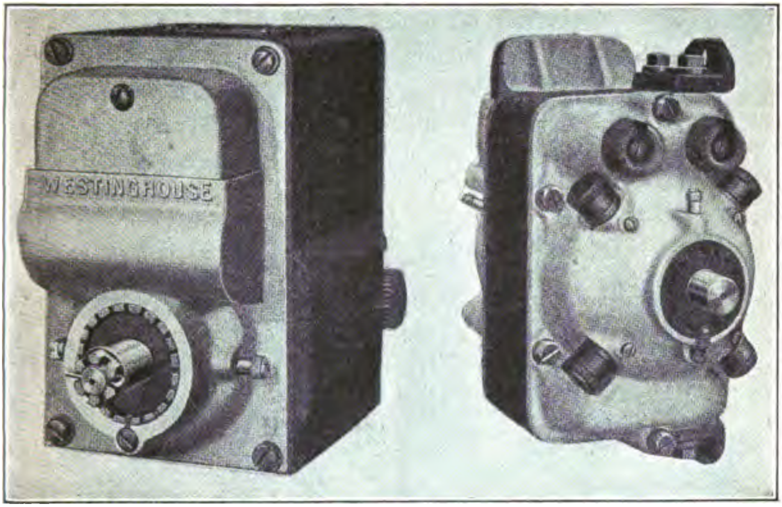


Fig. 149.—Two Types of the Westinghouse Current Generators.

at the right of Fig. 149 as it appears when viewed from the commutator end.

In practically all systems an amperemeter (Fig. 145) is mounted on the dash so that it can be readily inspected by the driver, this indicating at all times the amount of current being produced by the dynamo or drawn from the battery. If the indicating needle of the amperemeter points to the left of the zero point on the scale, it means that the battery is furnishing current to the lights or other current consuming units or discharging. When the needle points to the other side of the scale, it means that the

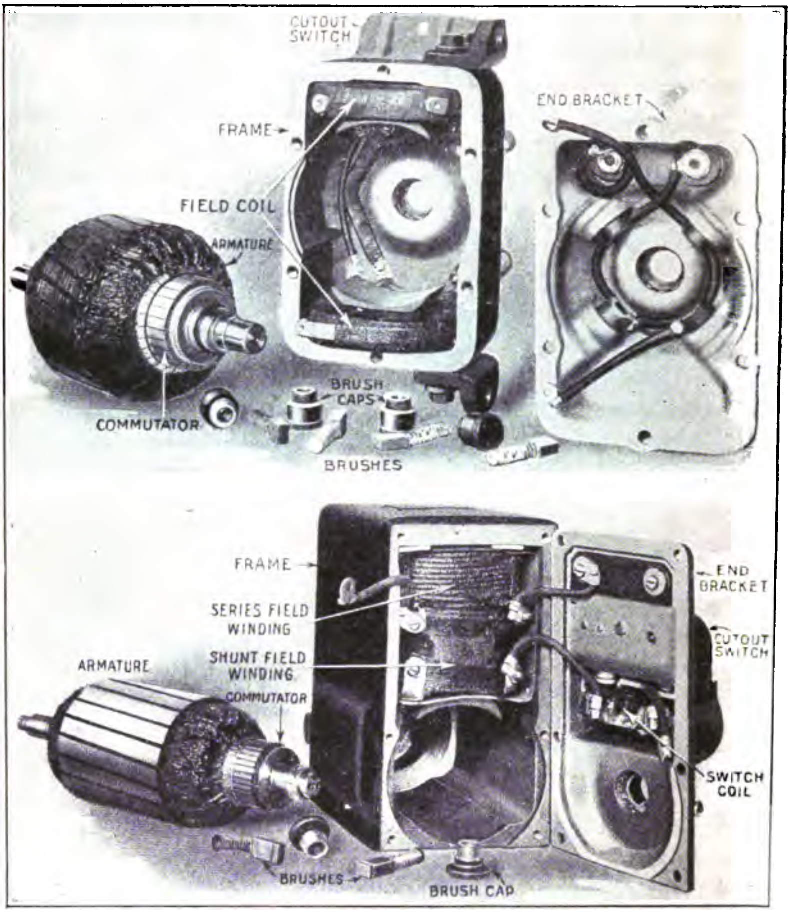


Fig. 150.—Westinghouse Current Generators Dismantled to Show Interior Construction.

generator is delivering current to the battery which is charging it, the amount of charge or discharge at any time can be read from the scale on the face of the amperemeter. Some of these instruments have the words "charge" and "discharge" under the scale in order to enable the operator to read the instrument correctly.

Another important element is the lighting switch, which is

usually mounted at some point within convenient reach of the car driver. This is often placed on an instrument board on the back of the cowl in connection with other registering instruments. As ordinarily constructed, the switches are made up of a number of units, and the wiring is such that the head, side and tail lamps may be controlled independently of each other. For simplicity and convenience of installation, the switch is usually arranged so that all circuits are wired to parallel connecting members or "busbars" placed at the rear of the switch. In some cars, as the latest Overland and the White models, the switch units are placed on the steering column. As but little current passes through the lighting switch the contacts are not heavy in construction as are those of the starting switch.

The function of the starting switch is to permit the current to flow from the storage battery to the starting motor, when it is necessary to start the car. It is arranged usually so as to be readily operated by the foot and is nearly always installed at some convenient position on the toe board of the car. As we have previously shown, the starting switch is often interlocked with the starting motor gearing so that the operation of engaging the gear with the flywheel and of turning on the current to the starting motor are accomplished simultaneously. The lighting and motor starting wiring systems are independent of each other, and may be easily found as that used to convey the high amperage starting current is of heavy round single conductor cable, while the lighting wiring is usually a light multiple strand cable. In order to prevent chafing and depreciation of the insulation the wiring is often protected by conduits of a flexible metal tubing, and the terminals are extremely heavy and well adapted to resist the vibration which is unavoidable in automobiles.

In a paper read by Benj. F. Bailey, of Michigan State University, before the Detroit section of the A. I. E. E., some interesting deductions are presented showing the influence of voltage desired on the electrical equipment, also reasons why the Edison storage battery, which is so well adapted for lighting or ignition is not equally suitable for starting purposes.

On account of the somewhat fragile nature of the filament of

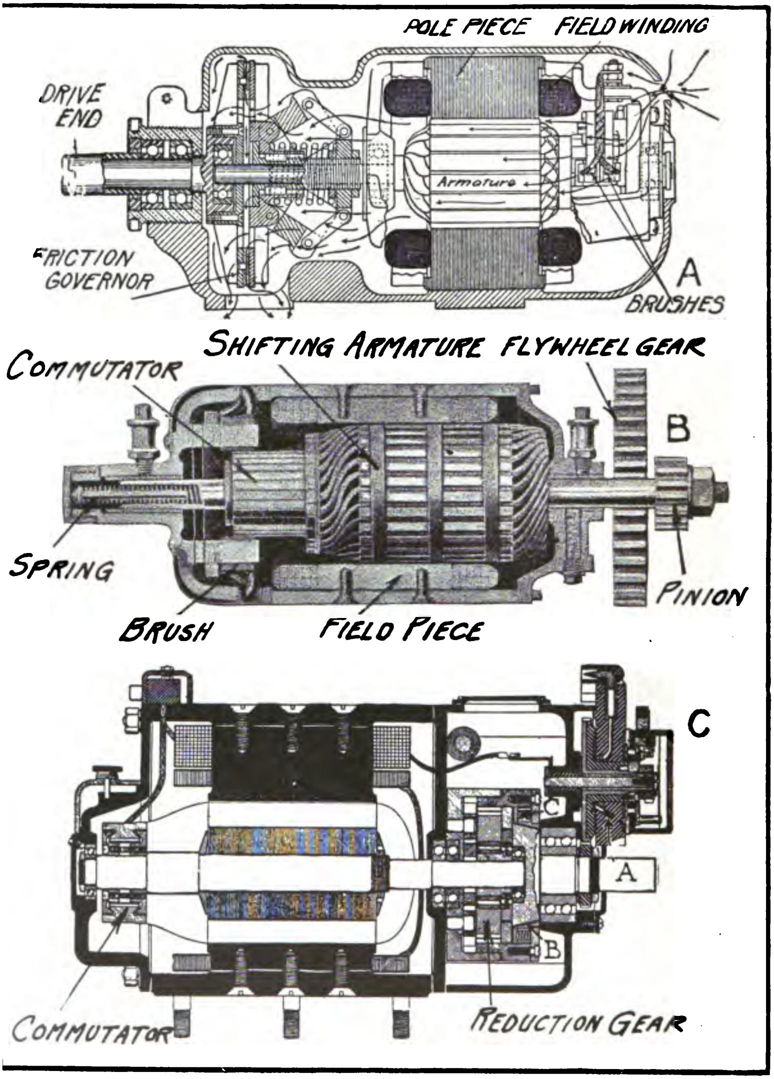


Fig. 151.—Showing Construction of Typical Generators and Starting Motor.

an electric lamp it is not advisable to attempt to operate small lamps at a high voltage, since a high voltage lamp requires a long, slender filament. Practice in this country has practically standardized the six-volt lamp, and there seems to be no valid reason for making a change. This being the case the total voltage of the battery is always some multiple of six, usually 6, 12, 18 and 24 volts.

As far as the battery is concerned the smaller the number of cells the better. A certain minimum of stored energy is necessary and this can be provided with less weight and at a lower cost in a few large cells than in a greater number of small ones. The smallest possible cell using a certain size of plate would have three plates, one positive and two negatives. A cell of double this capacity would require only five plates, two positives and three negatives. The weight of the container would be only slightly greater, and the whole cell would weigh decidedly less than twice as much as the small one. Thus it happens that a battery capable of supplying a certain amount of energy at 12 volts will weigh approximately 35 per cent. more than a battery of the same capacity at 6 volts. The cost of the 12-volt battery will also be about 35 per cent. more. The labor of caring for the battery and the chance of trouble due to a broken battery jar are about doubled.

Good starting motors may be built for any voltage from 6 to 24. Comparing a 6-volt motor with a 12-volt, the commutator of the former would have to be much larger than that of the latter. This means not only added cost of construction but the loss in the larger commutator is approximately twice as much as in the smaller. As this loss is large in any event the efficiency of the 6-volt motor is perhaps 1 or 2 per cent. lower than that of the 12-volt. The designer of the 6-volt motor is also seriously hampered in his choice of windings, and frequently cannot get just the combination needed to give the exact characteristics desired. For example, the calculation might show that 1½ turns per coil were desirable. He would be forced to use either 1 or 2. With the same characteristics the proper number for the 12-volt machine would be 3, and we should have a good chance to vary the characteristics by using 2 or 4 turns. In spite of these facts the 6

volt motor can be, and is, made to have very good characteristics.

As regards the generator, there is very little to choose. The efficiency, cost, etc., of the two would be practically identical.

The wiring would be somewhat simpler and the switches simpler and cheaper on the 6-volt system since with 12 volts it is customary to connect the lamps on the three-wire system. A slight advantage of the 12-volt three-wire system is that a single ground would not extinguish all the lights but only those on one side.

Single Wire vs. Two Wire Wiring.—Assuming that a six-volt system is used there arises the question of whether one or two wires should be used; that is, whether or not it is allowable to use the frame as the return wire. The writer has always used the single-wire system and believes it to be the better, all things considered. It certainly is the simpler and with the same expenditure as the two-wire system can be made fully as safe against breakdown. Practically all our large buildings are wired on the three-wire plan, the neutral being grounded to the steel frame of the building. There then exists everywhere a pressure of about 110 volts between the conductors and the conduits containing them. If this can be done it should be a simple matter to insulate for six volts. In the writer's opinion the wiring is a very important part of the installation and it is one that is often neglected.

Type of Battery.—Having decided upon the voltage to use the next point is the selection of a suitable battery. The question is often raised why the Edison nickel-iron cell is not used for electric starting. If it were a matter of lighting only, the Edison cell, in spite of its high first cost, would unquestionably find many users. The cell is capable of standing almost any amount of abuse; it can be short-circuited with impunity and can be left in a discharged condition for an indefinite period. Its efficiency is low, but that would not be a very serious matter to the average user. Four cells would be necessary in place of three, but the net weight for a given voltage and ampere hour capacity would perhaps be 10 or 15 per cent. less than that of a lead battery.

If, however, we attempt to use the Edison battery for starting

purposes we are confronted with the difficulty that it is impossible to operate it at high power outputs. This is on account of the high internal resistance. A 50-ampere-hour lead battery of three cells will weigh about 45 pounds, compared to about 37 pounds for a four-cell Edison battery of the same capacity. It is not an uncommon practice to take as much as 135 amperes from a lead battery of this size with a terminal voltage of 5.2. The output is then $5.2 \times 135 = 702$ watts, or 0.94 horsepower. The internal resistance of the Edison battery is such that it would be entirely out of the question to provide a battery which would yield this same power with the same voltage drop; i.e., at the same efficiency. If we decide to allow a much greater drop we might use the Edison A-6 cell. This has an internal resistance of about 0.0024 ohm per cell. If we should take 194 amperes from four of these cells in series the drop due to internal resistance would be about 1.9 volts, giving a terminal voltage of about 3.62 volts. The power would be the same as before, or 702 watts. The weight of the four Edison cells would be 80 pounds, or nearly double that of the lead cells. The watt hour efficiency would be quite low.

An even more serious difficulty is the fact that the starting torque of the motor with the Edison cells would be far less than that with the lead cells. Thus the resistance of the motor used with the above cells would be about 0.0085 ohm. The internal resistance of the cells would be 0.0096 ohm and the current in case the motor did not start at once would be about 310 amperes. The internal resistance of the lead cells would be only about 0.006 ohm and the starting current would be 415 amperes. Since the starting torque increases even faster than in proportion to the current it will be seen that the starting torque with the lead cells would be about 35 per cent. greater than with the Edison battery. Thus the "leeway" or the "factor of safety" is considerably less with the Edison battery and the lead plate type is generally employed in starting systems.

Comparison of Two Unit and Single Unit Outfits.—Since most of the outfits in use to-day fall within one or the other of these two classes a somewhat detailed comparison of their char-

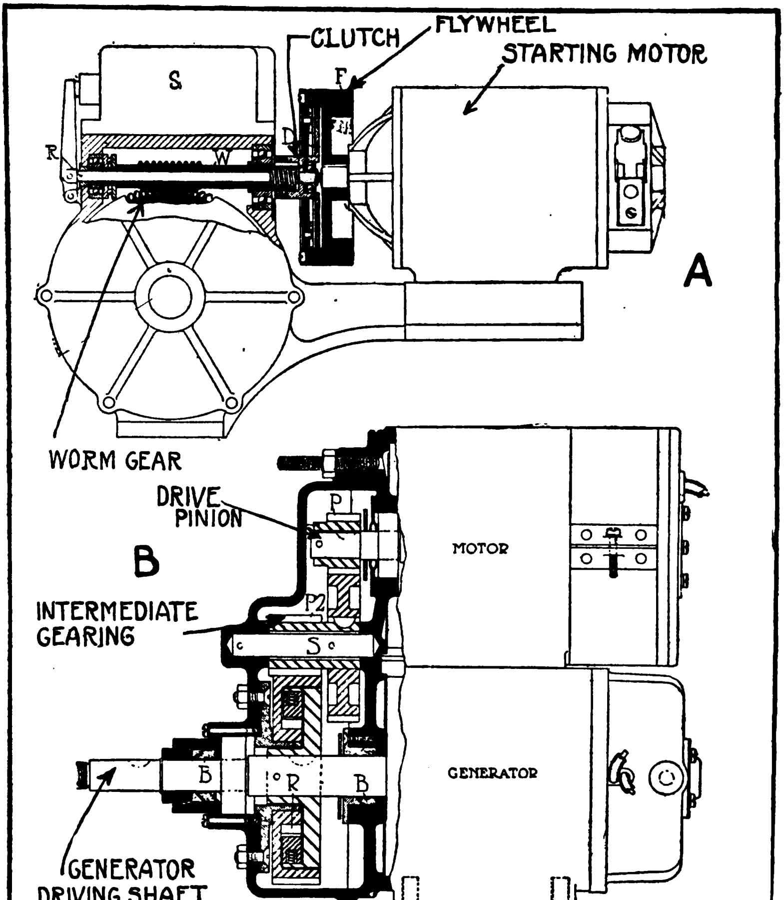


Fig. 152.—View at A Shows Hartford Starting Motor. At B—Clutch and Driving Arrangement of a Two Unit Outfit.

acteristics may be of interest. The operation of the single unit machine may be reduced to the pushing of a foot button, although as practically applied some such outfits require also the meshing of a gear. On the other hand, some two-unit outfits do not re-

quire a gear to be meshed, and consequently fall also in the "push the button" class. About all we can say is that the tendency is to design the single-unit machine so that no gears have to be meshed, while the two-unit outfit usually utilizes the flywheel in connection with the shifting pinion. This may seem like a very small point to most of us, but is not necessarily so to a large class who now drive automobiles and who know nothing and care less about the mechanism by which certain results are accomplished. All they want is the result and this attitude is perfectly justified.

To compare accurately weights, efficiency, etc., of two systems is rather difficult in general. The writer is, however, fortunate in having had the chance to design an outfit of each kind, and it is therefore possible for him to give fairly accurate figures. The general design constants as regards flux densities, commutation, etc., are almost identical and consequently the figures are comparable. The single-unit outfit is of the type in which two commutators and two windings are used, one being utilized in starting, while both are connected in series for lighting. The gearing is of the planetary type, and no gears are in relative motion when the machine is operating as a generator. The change from a ratio of 157 to 1 to two to one drive as a generator is made automatically by means of a clutch and centrifugal weights. The outside dimensions are 7 x 4 x 13¼ inches. These include all devices needed to connect and disconnect the outfit. The total weight with switches, etc., is 53 pounds.

The two-unit outfit comprises a generator 5½ x 5½ x 7¾ inches, weighing complete with disconnecting switch 17 pounds and a motor 5¼ x 5¼ x 10½ inches, weighing with clutch and switch 30 pounds. The end of the motor shaft carries a pinion which meshes directly with gear teeth cut in the flywheel face. There is, therefore, only a single reduction between the motor and the engine.

The capacities of the two machines when acting as generators are nearly the same, that of the single-unit system being somewhat greater. The capacities of the two motors at their maximum horsepower is nearly the same, being 1.43 for the single-unit set and 1.37 for the separate motor.

We must next consider the efficiency of the reduction gearing in the two cases. The writer was very much surprised when he first measured the efficiency of a double reduction gearing to find an efficiency of only about 65 per cent. This was true both of planetary gearing and of that of the type used in sliding gear transmissions as usually applied to automobiles. In this latter case the countershaft was mounted on ball bearings. On the other hand, the efficiency of the single reduction is high and has been taken here as 90 per cent.

Considering the motors alone, the efficiency of the single-unit set as a motor is lower than that of the motor alone of the two-unit set. This is on account of the greater amount of material subject to losses, the friction of the idle commutator and to the fact that the design is somewhat of a compromise between what is desirable for the generator and for the motor. The relative figures are 76 per cent. and 74 per cent. Considering also the gearing efficiency, the net efficiency from the motor terminals to the engine shaft is in the one case 68 per cent. and in the other only 45 per cent., most of the loss in the latter case being due to the gears. This is a rather serious matter since the cranking speeds with a given current output would be in the same ratio as the efficiencies. Thus, the single-unit set turned the engine over at a speed of 100 r. p. m., the two-unit outfit with the same current would give a speed of 151 r. p. m. To sum up the matter, the writer is convinced that the use of double or triple reduction gearing leads to a great loss in efficiency, perhaps a far greater one than is usually supposed.

It should also be noted that the motor in the above outfit might have been designed for higher speed and double reduction gearing. The motor would have been somewhat lighter and perhaps 1 or 2 per cent. more efficient. If we consider the total weight, including gears, it is questionable whether there would have been any reduction in weight, and certainly the efficiency would have been far lower. There is another way in which the use of single reduction gearing and a high efficiency motor act to reduce the weight of the installation, namely, they permit the use of a lighter battery. If the single reduction outfit is geared

to give the same speed with less current, the advantage is obvious. If, on the other hand, it is geared to take the same current and give a higher speed, it is likewise obvious that the number of *turns* required to start will certainly not be more and probably will be far less. Therefore, the time required to start will be inversely proportional to the speed or less, and the drain on the battery in ampere-hours will be reduced in the same proportion. It is hoped that the above will make clear that the matter of efficiency is not a minor question, but is vital to the success of the whole matter of electric lighting and starting. We shall have occasion to discuss the same question in connection with lighting generators.

To sum up the question of single versus two-unit sets, the writer (Prof. Bailey) from his experience, would rate them as follows:

Operation.—The single-unit set as ordinarily arranged has a slight advantage.

Weight.—For the same cranking speed and the same generator output the two-unit outfit is probably about 20 per cent. lighter. This might not hold for low speed cranking.

Efficiency.—The writer is convinced that both as a generator and as a motor the single-unit outfit is at a disadvantage. The efficiency as a generator will average perhaps 5 per cent. lower and as a motor about 2 or 3 per cent. lower. If, as is ordinarily the case, the single-unit set is operated with a double or triple reduction gearing, the efficiency of the gearing will be between 60 and 75 per cent. If the two-unit set is used it is practicable to use a single reduction and obtain the higher efficiency of 90 per cent.

Generators and Starting Motors.—Essentially there is not much difference in construction between a starting motor and a generator as the principles upon which they operate are practically the same. A machine that is capable of delivering current in one direction when driven by mechanical power will produce mechanical energy if electrical current is passed through the winding in a reverse direction. The construction of typical starting motors and generators may be readily understood if one refers to the illustrations at Fig. 151. That at A is one form of the

Gray & Davis governed dynamo, which is of the limited armature speed type. The power is directed to the driving member of a friction clutch which turns the generator armature by means of friction contact with a disc attached to but slidably mounted on the armature shaft. This plate is held in contact by a coil spring. A pair of hinged governor arms are attached to the driven clutch plate, while the other ends are attached to a rotating spider member fastened on the dynamo armature shaft. When the speed increases beyond a given point the governor weights fly out, due to centrifugal force, and reduce the amount of frictional adhesion between the clutch members in proportion as the armature shaft speed augments, until the point is reached where there is no frictional contact between the parts of the clutch and the driving plate is turning at engine speed, while the driven member that imparts motion to the armature is gradually slowing down and permitting the tension of the coil spring to overcome that force produced by rapid rotation, and to bring the discs in contact again for just a sufficient length of time to enable the armature to maintain its rated speed even if the engine is running faster than normal.

A typical starting motor, which is of the Rushmore design, is shown at B. As will be evident, this is practically the same in construction as the generator shown above it, as far as essentials are concerned, except that no governor is provided and the armature shaft is fitted with a small spur pinion designed to engage with the spur gear on the engine flywheel. No mechanical interconnection is necessary between the drive pinion and the electrical starting switch. As soon as the current flows through the armature of the motor it will move that member laterally and automatically engage the pinion of the flywheel gear. As soon as a starting switch is released, a coil spring will push the starting motor armature back again in the position shown in the illustration, and thus automatically bring the pinion out of mesh with the flywheel gear. In order to obtain a sliding feature this motor armature shaft is mounted on plain bearings instead of ball bearings, which are standard equipment on practically all machines of this nature.

The device outlined at Fig. 151, C, shows the construction followed when the ignition function is combined with a current generator and starting device having the three functions performed by one instrument. The general construction is the same as in the device previously outlined. The drive shaft of the device is adapted to be attached to the engine by direct mechanical means.

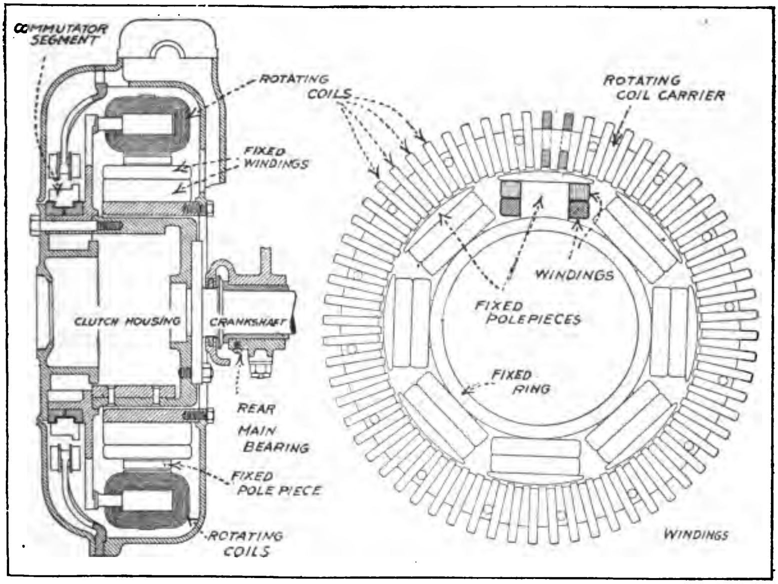


Fig. 153.—Diagram Showing Construction of U. S. L. Flywheel Type Dynamo Motor.

When the device is used as a current generator, the armature is driven by the shaft, whereas if the device is used as a motor the armature drives the shaft A through a planetary reduction gearing and roller clutch. Regardless of whether the device is used as a motor or generator, the distributor for ignition purposes is driven in the same direction, and at the proper speed to insure ignition as it is driven directly from shaft A, which turns at crankshaft speed.

An example of a double deck combined instrument in which the

generator is carried in the lower portion of the casing and the starting motor at the upper part is clearly shown at Fig. 152, B. The partial section makes clear the arrangement of the reduction gearing and roller clutch. This type has met with favor because it is mounted easily, and also on account of the simple mechanical connection to the engine. While the two units are electrically separate, i.e., each having its own field and armature, it may be considered as one unit mechanically. The double deck instrument shown is designed for application to the side of a gasoline engine connecting by chain or gearing to the pump or magneto drive shaft. It should be noted that this chain or gear is the only connection between the machine and the engine, and that it is used not only for transmitting the engine energy to the generator, but also acts to transmit the power from the starting motor to turn the engine crankshaft when it is desired to start the power plant. It will be apparent that in a combined instrument of this type that it is necessary to have a fairly low gear ratio between the motor and the engine in order to reduce the high speed of the motor armature rotation to a speed low enough to turn over the engine crankshaft.

At the other hand, once the power plant is started the generator armature must turn at a slower speed than that of a starting motor, and if it is run from the pump shaft or magneto drive shaft it will turn fast enough to generate the proper quantity of electricity. The starting motor, however, must be geared down in order that it may exert the starting torque through the high leverage furnished by the reduction gear. The motor occupies the upper position, and carries a pinion P keyed to the end of its armature shaft. This pinion transmits the drive to an intermediate shaft S, which in turn drives the large gear forming the outer casing of an overrunning roller clutch R. The inner or driven member of this clutch is mounted rigidly on the armature shaft of the generator and carries the drive through to an outer chain gear when cranking the engine. As soon as the engine explodes and the speed runs above that represented by the starting motor at the roller clutch the latter comes automatically out of action, thus permitting the generator to obtain its power in the normal way through

the chain wheel attached to the dynamo shaft. The motor armature above comes to rest as soon as the starting switch is released. The generator of this device has its output controlled by a combination of armature reactions and a bucking coil, while the battery is protected from discharging back through the generator by a simple magnetic contact breaker or cut-out. The starting motor shown at Fig. 152, A, is a one-function instrument having worm reduction gearing.

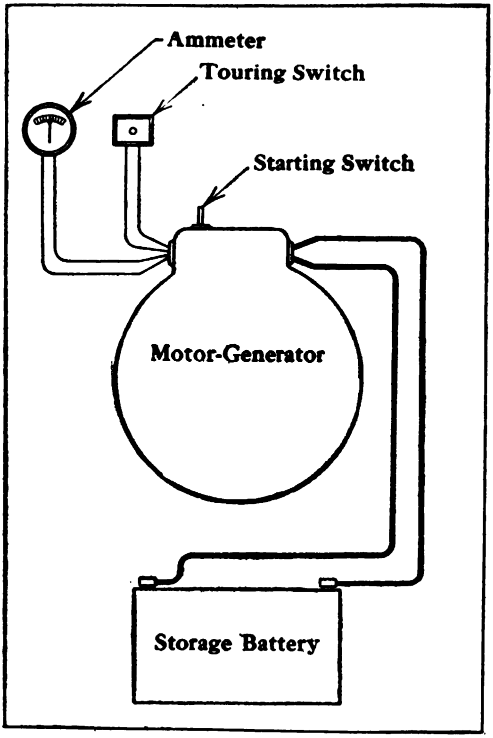


Fig. 154.—Diagram Showing Simple Wiring of U. S. L. One Unit Starting and Lighting System.

The motor generator unit used in the United States Lighting system differs from any other form, in that the device is incorporated in the flywheel housing and is driven directly from the motor crankshaft without the interposition of any driving gearing or chain. This construction is shown at Fig. 153, which shows a side view of the generator installed in the flywheel compartment and a face view showing the relation of the fixed and rotating members. A series of fixed pole pieces is attached to a ring bolted to the flywheel case while the rotating pole carrier is driven from the clutch housing and takes the place of the engine flywheel.

When current is passed through the fixed field the rotating armature member will be forced to rotate and turn the crank-

shaft over. Similarly as soon as the engine starts revolving under its own power the device becomes a generator. The wiring is extremely simple, as is outlined at Fig. 154. This shows only the wiring of the generating and motor starting functions and does not show any lighting or ignition circuit, though these may be taken

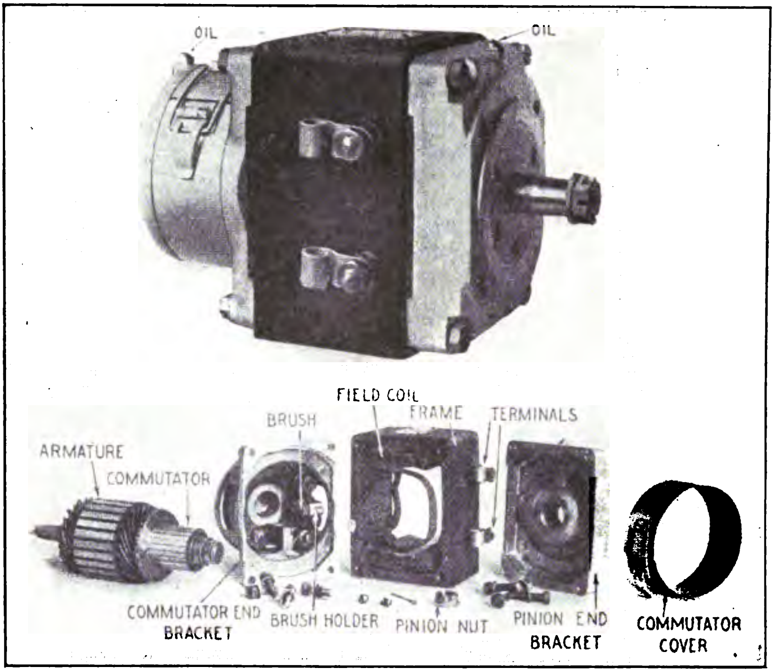


Fig. 155.—One Type of Westinghouse Starting Motor and Parts Comprising the Assembly.

from the battery in the usual manner. The lighting system operates on six volt current, though the starter requires a 12 cell or 24 volt battery. The lighting current is taken from only three cells of the battery.

The Westinghouse motors, generators, and motor-generators are designed particularly for their location alongside the engine, under the hood. As they are entirely enclosed, they are not

affected by dirt, oil, gasoline or water. The end frames that carry the bearings are machined magnalium castings of substantial design, and are each fastened to the frame by heavy screws with lock washers, effectively preventing vibration from disturbing the alignment of the bearings. The size and proportions of the machines are such that they can be conveniently located without interfering with the balance of the car equipment. The frame is

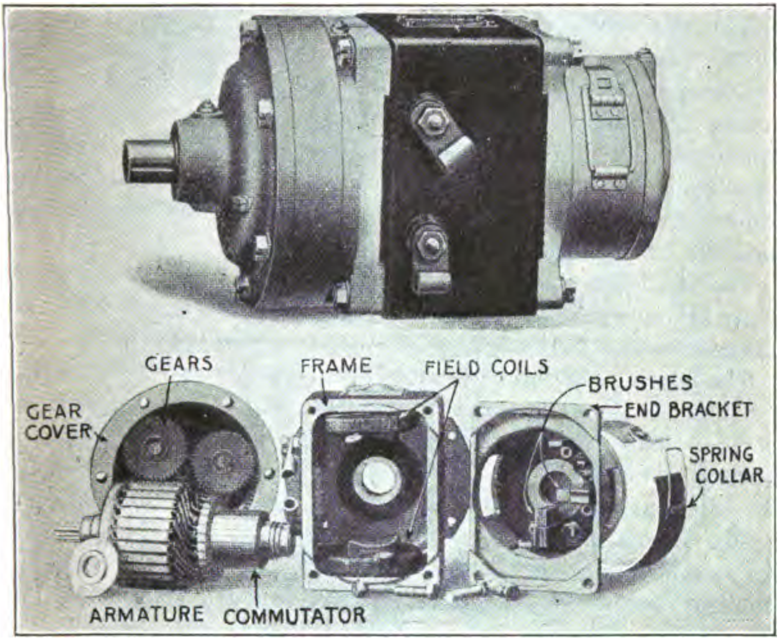


Fig. 156.—Westinghouse Starting Motor with Self-Contained Planetary Speed Reduction Gearing.

of cast steel (except the smaller motors), which not only gives ample strength, but because of its high magnetic permeability results in a saving in weight.

The armature is of the laminated drum type, with windings laid in slots. A special insulation is used, which after treatment makes the armature a solid mass that does not soften even at a

continuous temperature of 250 degrees Fahrenheit. It will stand even higher temperature for short periods. The insulation and treatment absolutely prevents the winding from working loose under vibration, and makes it impervious to oil, water, and gasoline. The design provides for easy removal of the armature.

The field coil winding is also treated with the same insulating composition and cannot possibly jar loose. Wherever possible, aluminum wire is used to reduce the weight. The insulation is applied by a special process that saves space.

The commutator and brushes are of proper proportions and of sufficient size to last for years without renewal of either. The brushes are mounted firmly, and can be removed and replaced without the use of tools. The current is carried to the brush by a low-resistancce copper shunt, and not by the brush spring. Proper silver-tipped connections are made by the brushholders when the brushes are inserted.

The shaft has a large diameter. The motor shaft has either square or taper end, as desired. A Woodruff key is provided, and a large locknut and washer, held by a spring cotter.

The bearings of the generators are magneto type ball bearings of a high grade, requiring minimum space. Starting motors are provided with either ball bearings or plain sleeve bearings. A starting motor receives such a small amount of actual running that ball bearings are a refinement not actually required.

The Westinghouse generators are shown at Figs. 149 and 150. The simple form of motor shown at Fig. 155 is intended for use with external reduction gearing. That depicted at Fig. 156 has internal planetary gearing to give the required speed reduction between motor armature shaft and engine crankshaft.

Generator Driving Methods.—When electric lighting was first applied to automobiles it was not considered necessary to drive the generators by positive connection, and the early devices were furnished with pulleys for flat or V belt drive. At the present time it is considered highly important to provide a positive mechanical connection that will not slip between the generator and the engine crankshaft. The common systems where the generator is a separate unit from the starting motor and in those forms where the

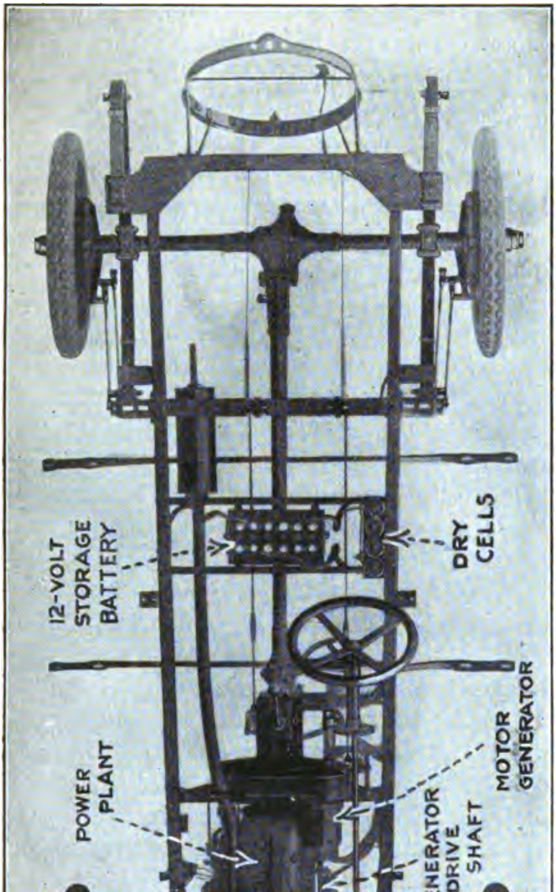


Fig. 157.—Plan View of 1916 Maxwell Chassis Showing Location of Starting System Parts. Note Belt Drive to Generator Driving Shaft.

starting and generating functions are combined, involve a connection with the motor crankshaft through some form of gearing. As shown in Fig. 144, the generator is driven by means of a leather universal joint connection with an extension of the pump shaft. The motor crankshaft imparts its power through the camshaft timing gear to the small pinion utilized in driving the water pump. In the generator application shown at Fig. 157 a belt is used, and at Fig. 158 the armature is rotated by silent chain connection with a gear on the motor crankshaft. There is not the diversity of drives for the generator as there is in the methods of connecting the starting motor to the end of the crankshaft.

In describing the advantages of silent chain drive the Dyneto Company writes as follows: "The exact type of drive selected must, of course, depend upon conditions. If possible, use a silent chain drive, direct to the crankshaft, with a suitable casing so that the chain can run in oil with all dirt excluded. In our opinion this will give the most quiet, durable and efficient drive obtainable. We recommend, when space allows, the use of chains of ½" pitch x ½" width. When sprockets of small diameter must be used, chains of ⅜" pitch x 1" width will be satisfactory. Sprockets of less than 15 teeth should *never* be used; 17 teeth would be much better. The efficiency of a good chain drive, well installed, is from 94 to 96%. If a gear drive is used, the gears must be of the best material and large enough to stand up under the enormous strains of starting. It is usually impossible to design a suitable gear drive of single reduction, and where three or four gears are used the drive is apt to be noisy, and certainly will be very inefficient. In tests of drives, using four gears in the train, spiral cut teeth, we have found an efficiency of less than 65%. A useless waste of 35% makes it necessary to use a larger starter, a larger battery, larger wires, and in fact the whole outfit must be much larger than otherwise would be necessary."

Starting Gearing and Clutches.—In order to show the variety of driving means used in connecting the starting motor to do the work of turning over the engine crankshaft, the leading systems have been grouped in one illustration at the top of Fig. 159. Starting from the front of the motor, the first method shown is by means

of a worm gear initial or primary reduction and chain connection from the worm-driven shaft to the motor crankshaft. In some cars the worm reduction is used having the starting motor mounted at the side of the change speed gear box instead of attached to the motor crankshaft. The reduction in speed may be by means of the

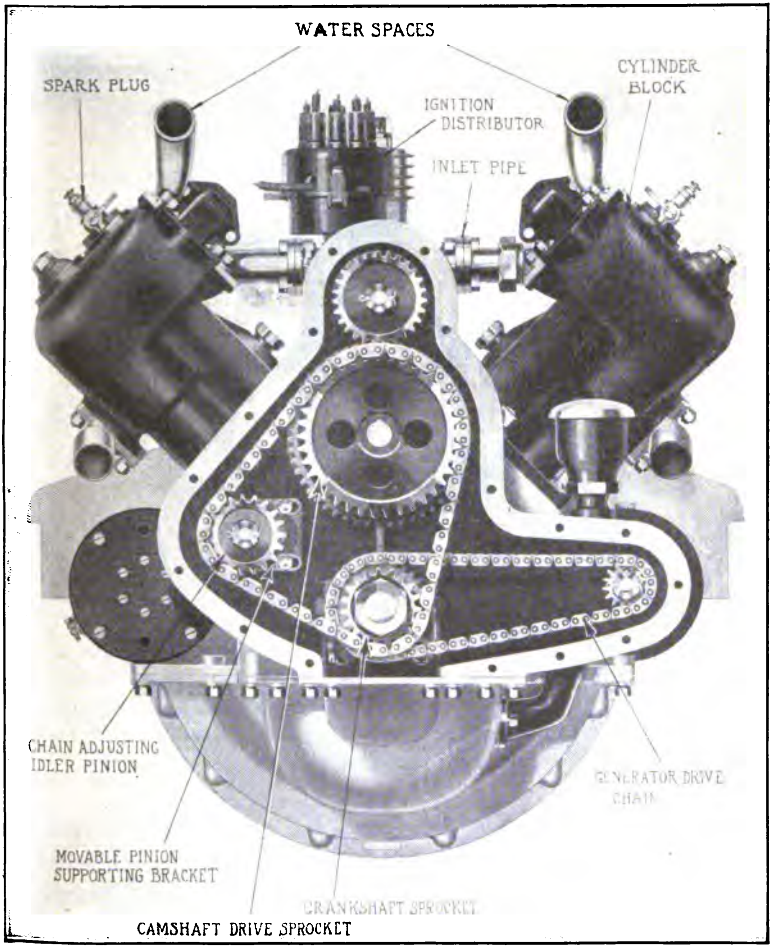


Fig. 158.—Front View of King Eight Cylinder Power Plant Showing Silent Chain Drive to Generator.

spur gears and chain, as shown at A-2, or by a chain to a shaft connected with the timing gear, as in A-3. The method at A-4 is a very popular one, including a reduction to an intermediate shaft, which carries a sliding pinion designed to engage the gear on the flywheel rim. The method at A-5 is used with the Rushmore starter, the

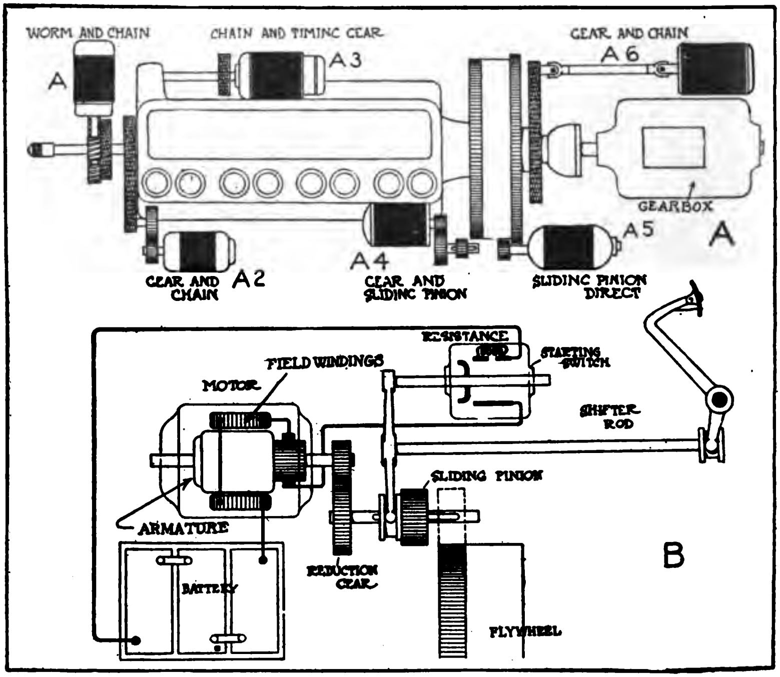


Fig. 159.—Diagram Showing Methods of Transmitting Power of Starting Motor to Gasoline Engine at A. Simplified Diagram at B Depicts Means of Interconnecting Starting Switch and Motor Starting Gear.

pinion being brought into direct engagement with the gear on the flywheel by the axial movement of the armature when the current is supplied to the field winding. The method at A-6 permits of attaching the starting motor securely to the frame side member at a point near the gear box, where it will be out of the way and not interfere with the accessibility of the power plant. When mounted

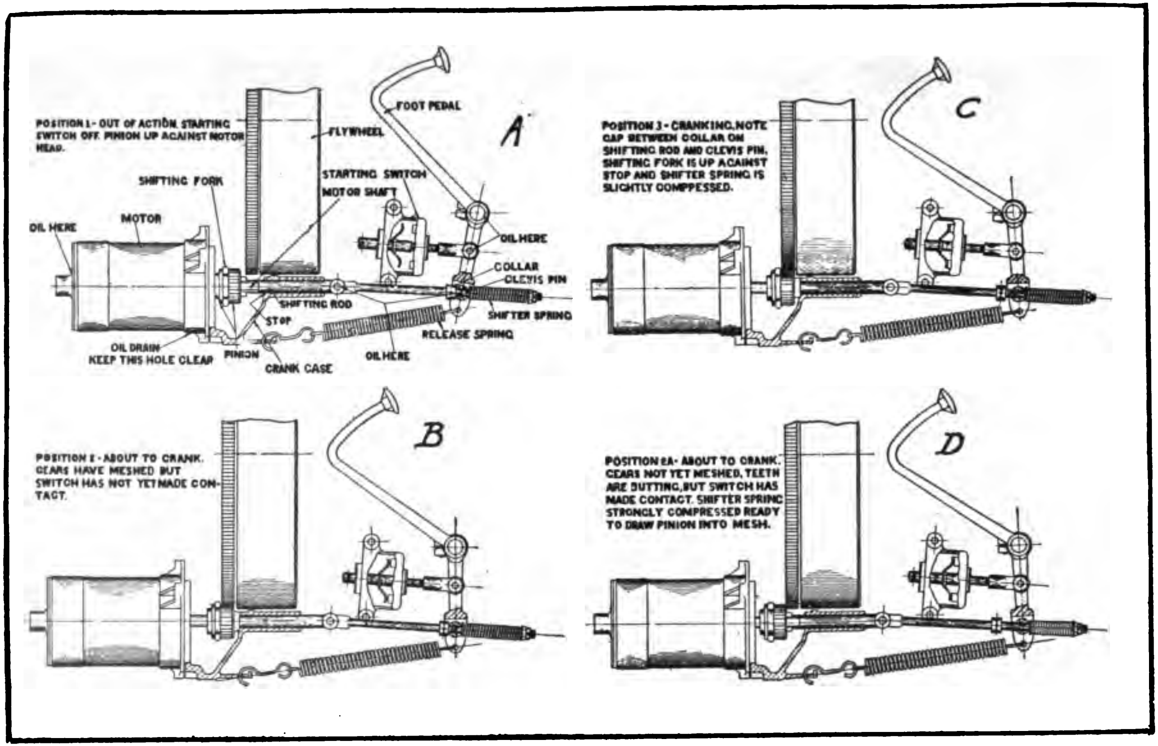


Fig. 160.—Showing How the Starting Switch and Shifting Pinion are Interconnected in the Bijur-Hupmobile Starting System.

in this manner the drive is by a double universally jointed shaft to a small silent chain sprocket, which connects to a much larger member attached to the engine flywheel or crankshaft.

The complete system shown at Fig. 159, B, is the next most popular of all that have been used. This shows the application of the starting motor, outlined at A-4. The mechanical interlock between the sliding pinion on the intermediate shaft and the starting switch is clearly shown. Before the pinion engages the gear on the flywheel rim the switch makes contact, but owing to the resistance interposed in circuit the motor will turn slowly to permit of more ready engagement of the sliding pinion. As soon as the pinion is fully engaged with the large gear the resistance is cut out and the motor draws what current it needs from the storage battery, this being enough to produce the torque necessary to turn over the engine flywheel and the crankshaft to which it is attached at such speed as will produce prompt starting. A system of this nature used on the Hupmobile in connection with the Bijur starter is shown at Fig. 160. In this the pinion is shifted by a spring connection as outlined at A instead of a direct rigid coupling. This makes it easier to engage the pinion as the switch can make contact as at D and the spring will draw the pinion in mesh. The spring is also useful under the conditions shown at B where the pinion engages readily but the switch has not yet made contact.

The actual application of the system, shown at A-1, Fig. 159, is outlined at C, Fig. 161. It will be observed that the starting motor is attached to the side of the engine in a vertical position and that it drives the intermediate shaft by means of a worm on the motor armature, which engages with a worm gear on the intermediate shaft, which also carries the driving sprocket, as shown at B. A further reduction in speed is obtained owing to the difference in size of the small sprocket on the intermediate shaft and that attached to the clutching member normally revolving free on the motor crankshaft. It will be seen that the motor armature is supported on ball bearings, and that one of these, backing the worm, is a double row form capable of sustaining both the end thrust and radial load imposed by the driving worm. In order to resist the end thrust on the worm gearing successfully a ball thrust bear-

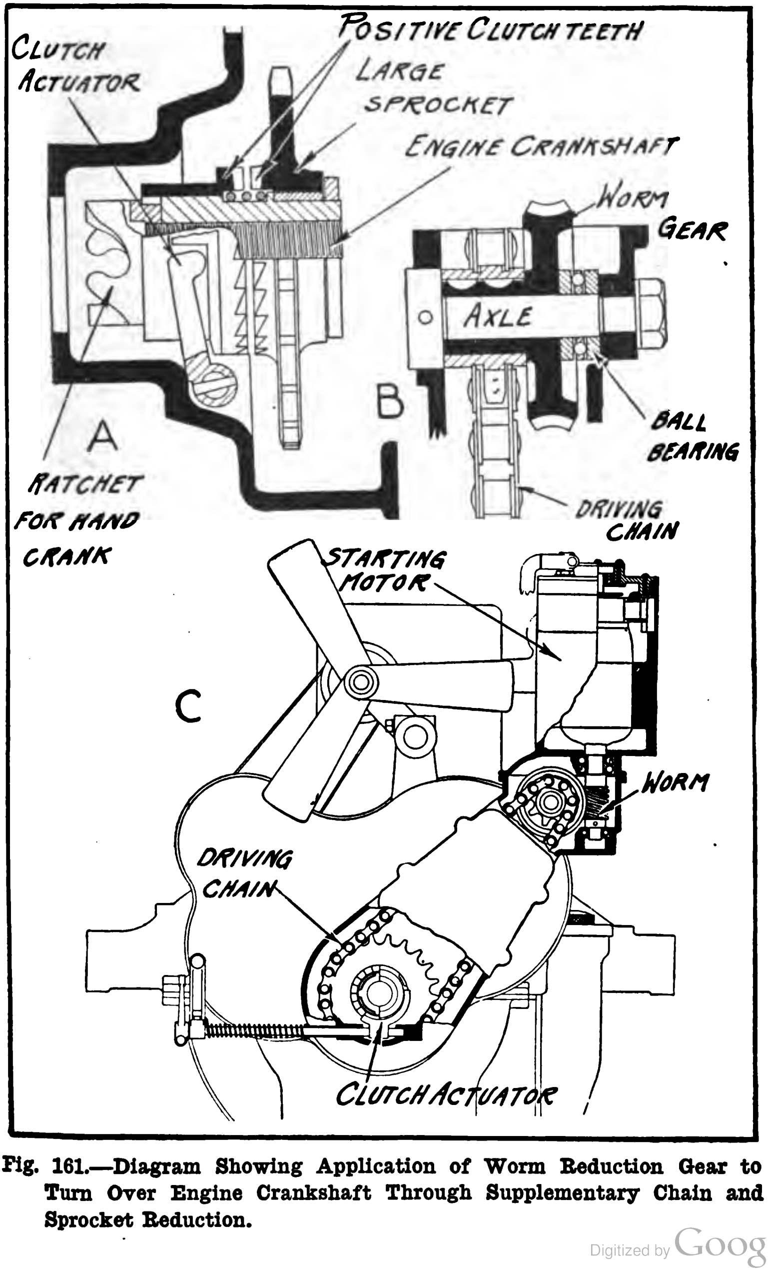


Fig. 161.—Diagram Showing Application of Worm Reduction Gear to Turn Over Engine Crankshaft Through Supplementary Chain and Sprocket Reduction.

ing is used, as shown at B. When it is desired to start the motor the clutch actuator, which is shown in the diagram at A, is pushed in until it engages the ratchet teeth cut on the face of the large sprocket. When the sprocket turns it must turn the engine crankshaft in the same direction, but just as soon as the engine runs faster than the large sprocket the clutching action will be released automatically by the ratchet teeth being thrown out of engage-

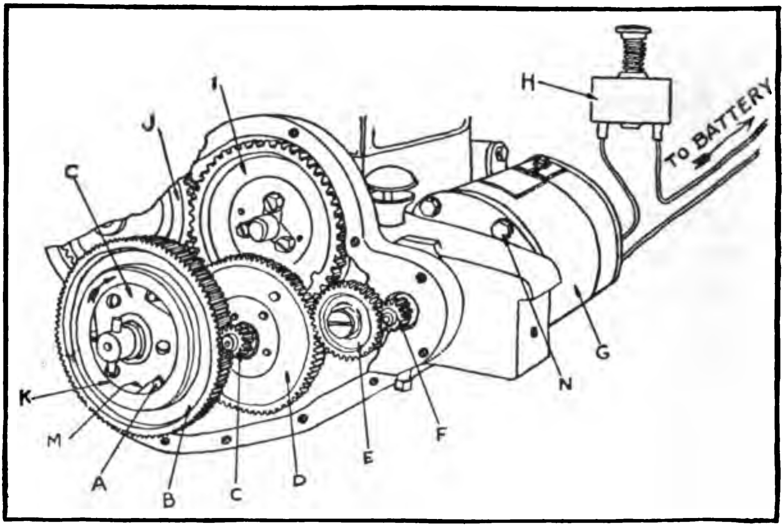


Fig. 162.—Diagram Showing Construction of Typical Overrunning Clutch.

ment. If it is necessary to start the engine by means of a hand crank this may be done by inserting the starting crank in the starting ratchet provided on the extreme end of the crankshaft. The large sprocket is normally free and the engine crankshaft turns without producing a corresponding movement of the sprocket member. The general arrangement of the parts is so clearly shown that no further description will be necessary.

The construction of a typical overrunning clutch is clearly shown at Fig. 162. The electric starting motor is secured to a base on the crankcase of the gasoline engine and the motor power

is imparted through the medium of the small gear F carried by the armature shaft. This drives gear E, which turns at a lower speed on account of being larger, and that in turn engages with gear D, which is still larger in diameter. The small pinion C, which turns much slower than the motor pinion F, meshes with the large gear B attached to the clutch body. The use of this gearing provides a

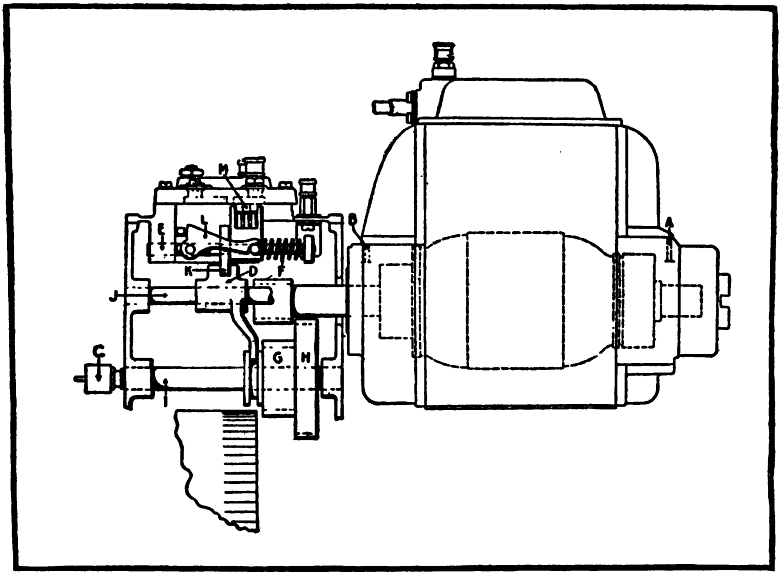


Fig. 163.—Showing Interconnection Between Starting Switch and Intermediate Pinion of 1914 Delco-Cole System.

reduction of 40 to 1, which means that gear F must make 40 revolutions to one of the clutch body.

The ratchet or driven member of the overrunning clutch L is pinned to the engine crankshaft and revolves with it when the motor is operating, rotating inside of the gear B, having a bearing at K and turning in the direction of the arrow. The member L has three flat surfaces, M, cut at an angle to the inside of the gear B. On each of these a hardened steel roller, A, is held inside of the gear by a light spring and against the flat surface of the member

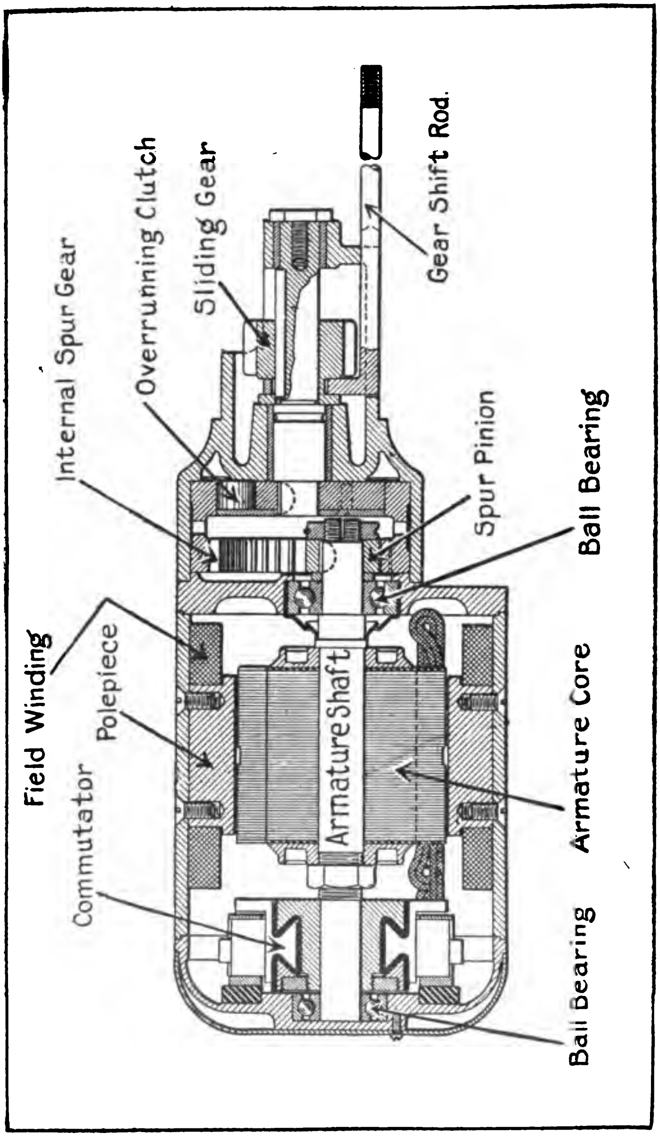


Fig. 164.—Sectional View of Typical 1914 Starting Motor Showing Reduction Gearing, Overrunning Clutch and Sliding Gear to Engage Teeth on Engine Flywheel.

L. The roller travels with the clutch and runs free against the side of the gear B when the engine is in motion and when the starting gears are idle. As soon as the current is directed to the electric starting motor, the three rollers are bound between the clutch body and the ratchet member carrying them and the crankshaft is driven until such time as the engine speed increases sufficiently to overrun that of the member attached to the crankshaft.

Overrunning clutches are not always used in those systems in which the gears are moved into engagement, as in that shown at Fig. 163, the clutch is omitted. It is used in the design shown at Fig. 164 however. In this former, the starting switch and the double shifting member, GH, are mechanically interconnected so that the starting switch will not be completely engaged until gearing is in mesh. The larger gear H of the sliding members meshes with that on the armature shaft, while the smaller of the pair, G, meshes with the flywheel. The arrangement of the parts outlined is used on the Cole car. In the Hartford starting motor, which is shown at Fig. 152, A, the clutch is of the friction type and is engaged automatically when the energy is passed through the motor winding to produce movement of the engine crankshaft. The reduction between the starting motor and the crankshaft is made by a worm and worm gear. When the switch pedal is depressed and the switch blades go into contact the same movement produces pressure on the end of the lever attached to R R, which transmits a strong pull on the friction clutch and thus connects the motor to the starting gear. The Ward Leonard combination is shown at Fig. 152, B. In this the motor is carried above the generator, and but one driving gear is needed to operate both the generator and to enable the starting motor to turn over the engine crankshaft. The speed reduction is by an intermediate gear shaft, the general operation being the same as that of the starter previously described.

Switches and Current Controlling Devices.—The various methods of operating the starting switch, which may be interconnected with the gearing to turn the crankshaft, are shown at Fig. 165. All of the methods of actuating the electric self-starter may be grouped into three main classes: one, by hand lever; two, by pedals, and three, by semi-automatic means. The method at A is

used on some Paige-Detroit cars, a hand lever, A, attached to the steering column being used to make the mechanical interconnection between the clutch pedal and the starting gear mechanism. In order to safeguard the gearing of the starter the electrical connection

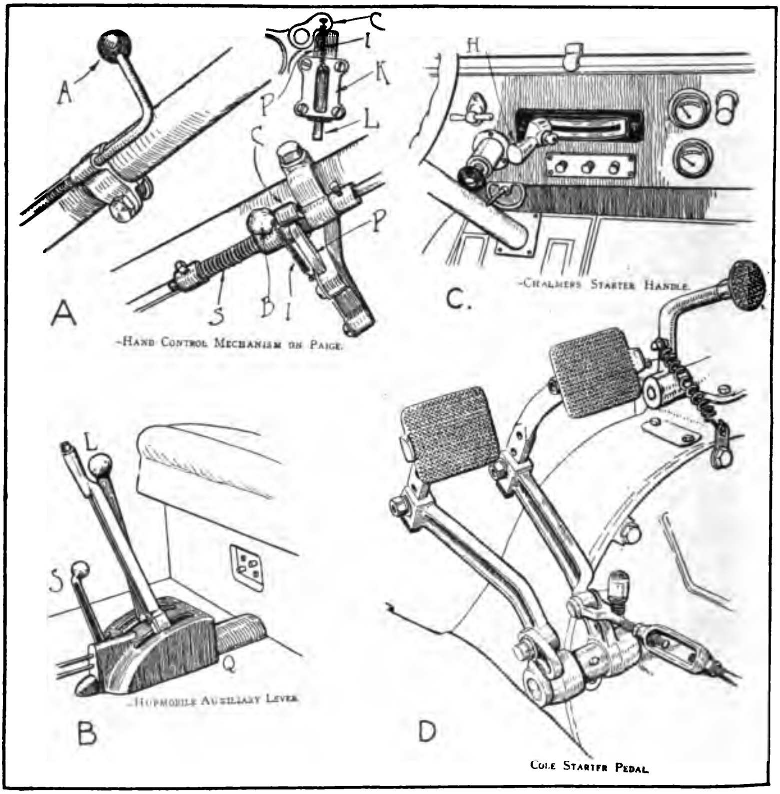


Fig. 165.—Methods of Actuating Motor Starting Mechanism.

cannot be effected until this mechanical interconnection is made. After the hand lever is thrown over in the proper position, depressing the clutch pedal suffices to permit the electrical connection to be made and the gasoline engine started. In the Hupmobile control, which is shown at B, a small auxiliary lever S is used to

put the starter into gear. The view at D shows a small pedal which is employed to make the starting connection. This is the most popular system, especially when the pedal is connected with the current-controlling switch, so that the full amount of current will not flow to the motor until the reduction gearing is completely engaged.

An example of the semi-automatic method which is used on the cars employing the Entz starter, namely, the Franklin, Chalmers

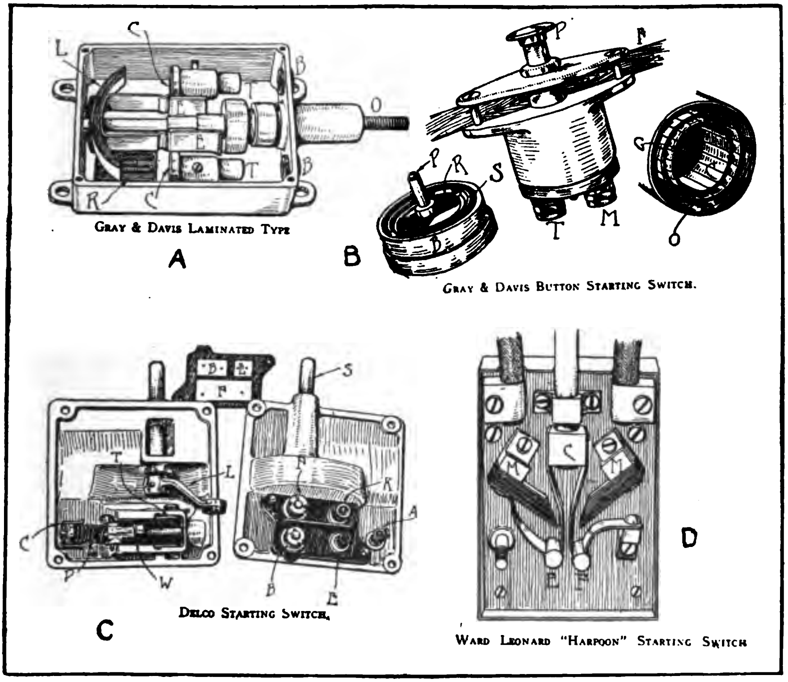


Fig. 166.—Construction of Typical Starting Switches.

and White, is shown at C. To put the starter in operation it is only necessary to move the handle H on the dashboard or other convenient position, where it may be readily reached with the hand or foot. This method is called the semi-automatic, because the starter operates all the time until the gasoline engine is stopped by short circuiting the ignition. The first step is to throw the han-

dle to the ignition point, and after closing the ignition switch, it is moved in the same direction until the storage battery has been connected to the starter generator. It is not necessary to touch the handle again until one desires to stop the engine, as moving the handle to the other extreme of its operating quadrant first opens the connection between the storage battery and the motor generator and then interrupts the ignition. With this starting system, if the

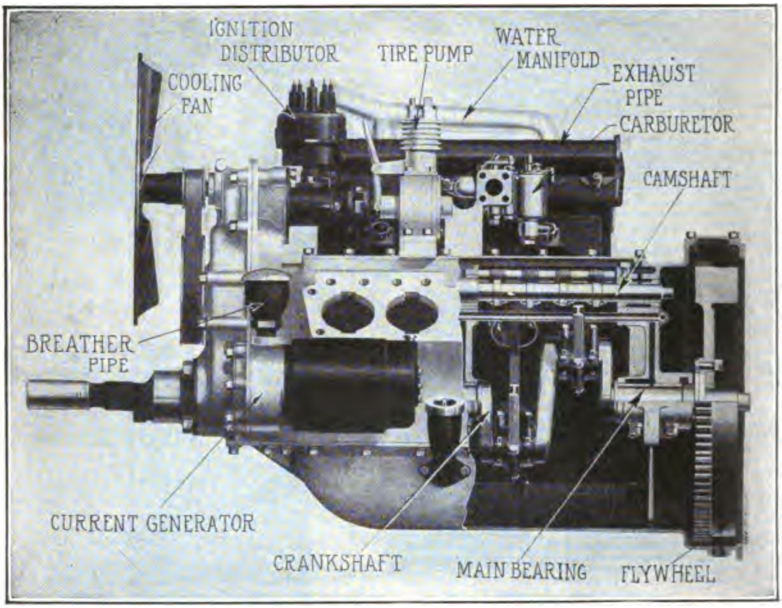


Fig. 167.—Side View of King Eight Cylinder Power Plant Showing Location of Current Generator and Ignition Distributor.

motor should be stalled for any reason or slow down below its normal cranking speed the starting motor-generator unit automatically changes from a generator to a motor and turns the gasoline engine crankshaft, making it practically impossible to stall the engine with this type of starter.

Owing to the large amount of current starting switches must carry, they are made much heavier in construction than lighting switches. They must be mechanically strong and the contact areas

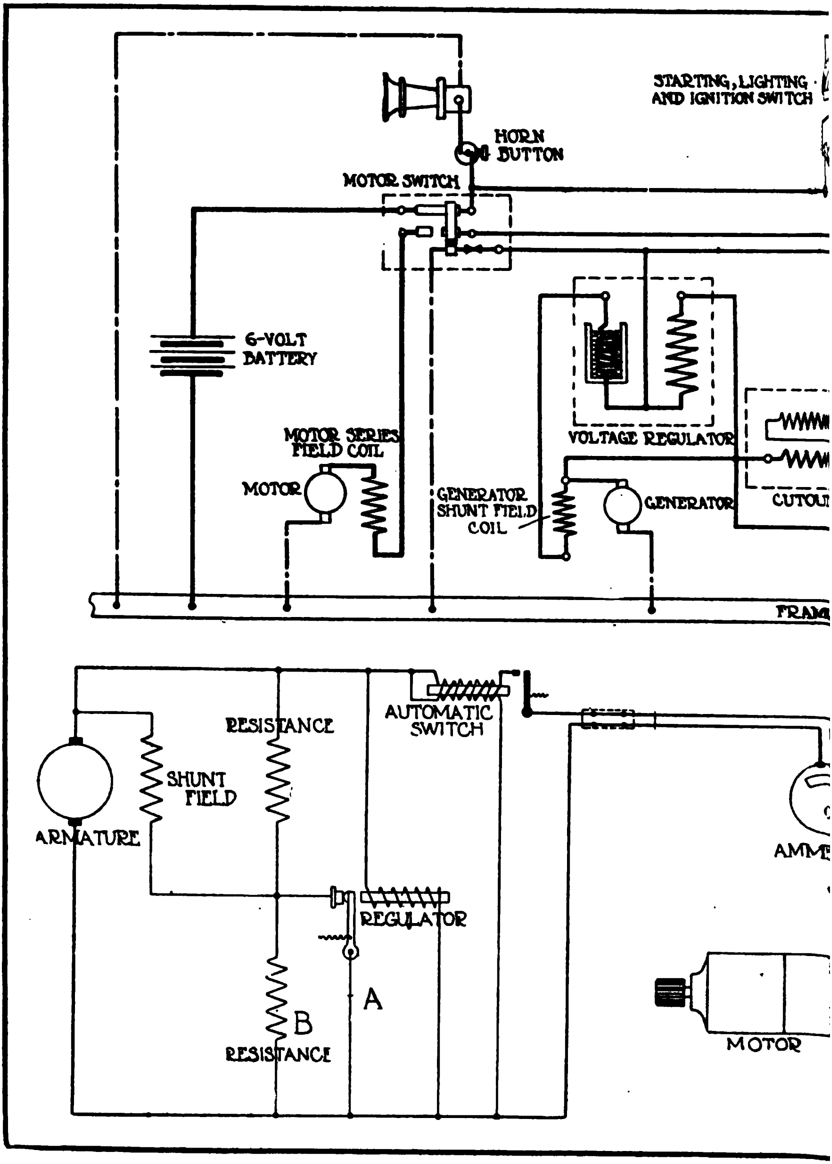
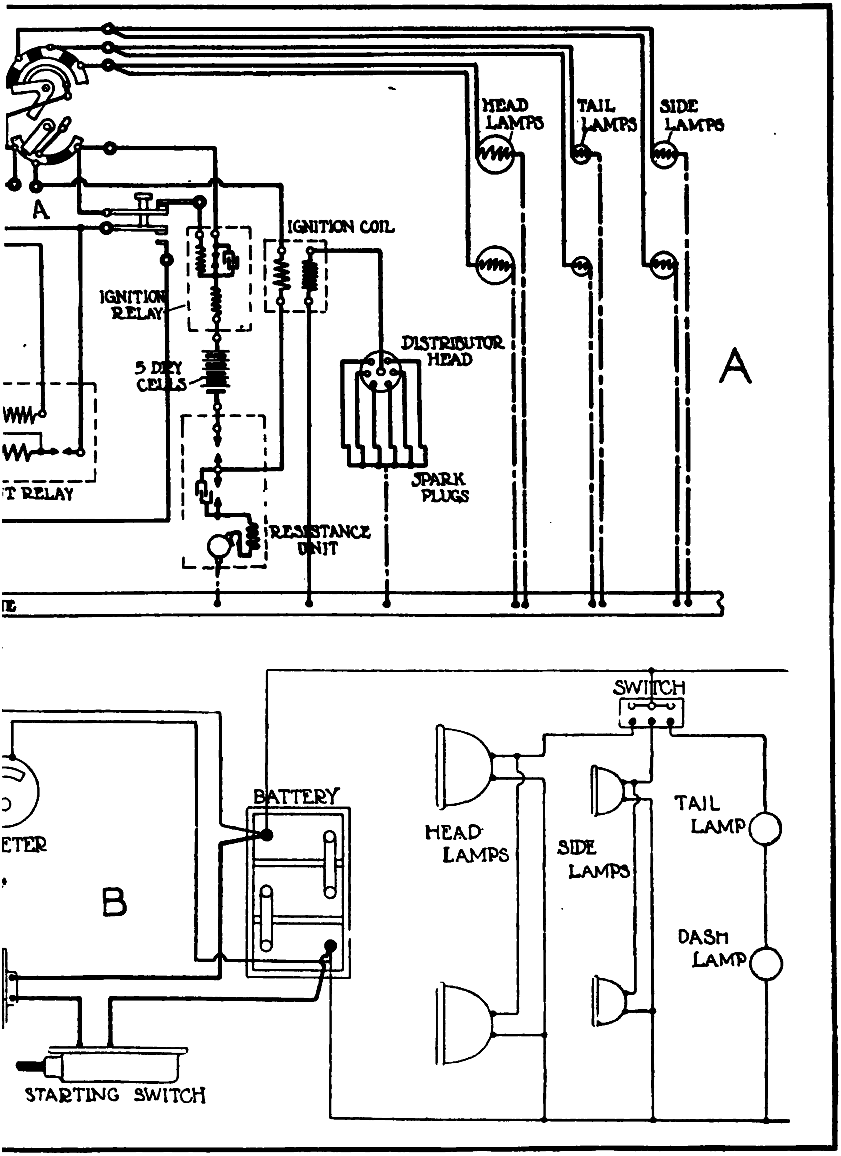


Fig. 168.—Wiring Diagram of 1914 Delco-Olds System Having Volta



ge Regulator at A and of the 1915 Bijur-Packard Starting System at B.

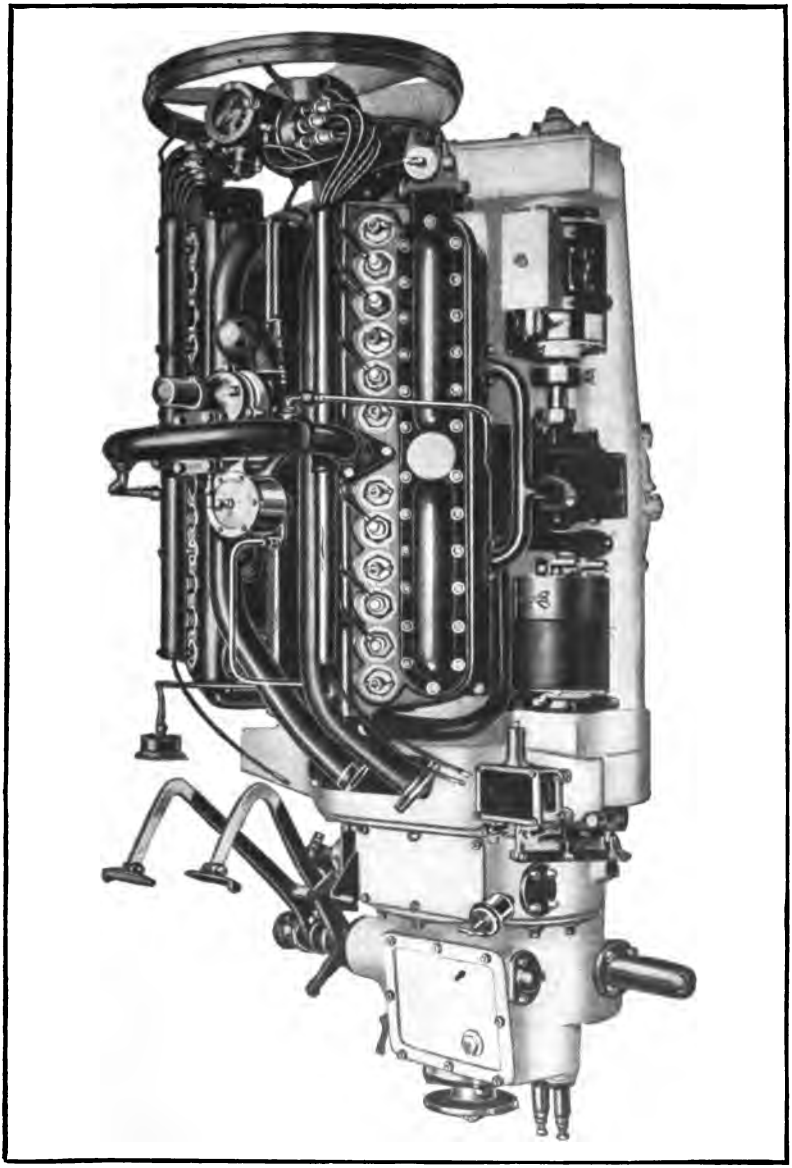


Fig. 168A.—View of Packard Twin Six Motor Showing Location of Generator and Starting Motor; Also Depicts How Compactly Parts May Be Arranged at the Side of the Engine Crank Case. The Special Delco Twin-Six Ignition Unit is Shown at the Front of the Engine.

be sufficiently large to pass a current of from 40 to 200 amperes, depending upon the voltage of the starting system and the size of the engine to be turned over. If the contact points were not of large area they would be very soon burnt. There are two types of starting switches in common use, one has only a single contact and is used on those systems in which the motor is connected at once directly to the battery terminal. The other type of switch has two sets of contacts, the first one completing a circuit through a resistance, the second one cutting out this resistance and permitting the maximum current to flow. The Gray & Davis laminated switch, shown at Fig. 166, A, is a two-contact form. A movement of the switch actuator first engages the blades with the contacts E E, then the arched contact piece L makes a connection with the pieces C C to allow the maximum current to pass. With the switch shown at D, which is also of Gray & Davis manufacture, there are no starting gears, and the only necessary operation is to direct the current directly from the battery into the starting motor winding. The switch is set in the floor boards of the car and is operated by the push rod P, which terminates with a button. The contacts C and O are circular in form and their free ends are turned away from each other so they may slip down over the members R and S, which are set in the insulating piece B. As soon as the pressure of the foot is released a spring returns the push button P and the electric circuit is broken.

The switch used on some of the Delco systems is shown at C. In the latest form the motor generator has two independent windings, both on the field and the armature. If the current from the battery is directed into the generator end the machine acts as a shunt motor and the armature rotates at a moderate speed. If the starting gearing will not mesh immediately when brought together a starting button on the dashboard enables the operator to pass the current through the generator winding, this causing the armature to turn over and facilitating meshing of the gearing. The main starting switch has only two points. In the off position the starter is connected directly to the battery terminal. An auxiliary contact on the starting switch breaks the circuit through the generator end and stops the current flowing when the device is used as a starting

motor. A heavy copper bar is moved across the face of the contacts B, E and F, the switch normally connects E and F, a feature which is necessary because of the dual functions of the combined motor generator. When the copper bar is moved to the left contacts B and F are brought into full electrical connection with one another and the entire battery current then flows to the motor. The contact pieces are molded into a piece of insulating material. The contact bar is pressed against them by means of springs.

Another form of laminated spring switch, which is known as the harpoon type, is shown at B. This is of Ward Leonard design. It is designed for use with a starter having flywheel gear drive, therefore it provides two contact points. The first contact with resistance in circuit is secured when the fingers C contact or make connection with the plugs E and F. Further movement of the switch short circuits the resistance by closing the main laminated contacts M M. These allow for considerable latitude of movement. The entire switch is built up on a piece of slate as a base and the resistance coils of wire are placed in the back of this base piece. The switches shown may be considered representative design, though the construction varies with practically every starting system. The writer is indebted to the Horseless Age for the illustrations at Figs. 165 and 166.

ELECTRICAL EQUIPMENT SPECIFICATIONS.

(*Courtesy of Horseless Age.*)

KEY:—D. U.=DOUBLE UNIT; S. U.=SINGLE UNIT; G. R.=GROUNDED RETURN; I. R.=INSULATED RETURN.

Make of Car	Make of System	Type	Make of Battery	No. of Cells	Capacity Amp. Hrs.	Voltage on Lamps	Voltage on Starter	Head-light C.P.	Type of Dimmer	Wiring System
YEAR 1912										
Cadillac.......	Delco........	S.U.	Exide......	12	80	6.5	24	16	....	I.R.
Cole.........	W. Leonard...	.....	Willard.....	3	60	6	..	21	....	I.R.
Empire.......	Remy........	D.U.	Willard....	3	100	7	6	15	Resist.	G.R.
Franklin......	Entz.........	S.U.	Willard....	9	35	7	18	21	....	I.R.
Haynes.......	Leece-Nev.....	D.U.	Willard....	6	100	6	12	..	....	I.R.
King.........	W. Leonard....	D.U.	Willard....	3	80	7.5	6	15	....	I.R.
Kline.........	Rushmore.....	D.U.	Willard....	3	120	6	6	24	....	I.R.
Lenox........	Splitdorf......	.....	Willard....	3	80	6	..	15	....	G.R.
Marmon......	Aplco........	.....	Vesta......	3	60	6	..	24	....	I.R.
Paterson......	Auto-Lite.....	D.U.	Willard....	3	80	6	6	12	....	I.R.
Peerless.......	Gray & Davis..	D.U.	Willard....	3	60	6–7	6	15	....	I.R.
Simplex.......	Rushmore.....	D.U.	Willard....	3	120	6–7	6	40	....	G.R.
Spaulding.....	Deaco........	S.U.	Willard....	3	50	6	6	21	....	I.R.
Stearns.......	Vesta.........	.....	Vesta......	3	60	6	..	15	....	I.R.
White........	White........	S.U.	Exide......	9	35	7	21	21	....	I.R.
White........	White........	S.U.	Exide......	9	60	7	21	21	....	I.R.
YEAR 1913										
Allen.........	Auto-Lite.....	D.U.	Willard....	3	120	6	6	15	....	I.R.
Apperson.....	Gray & Davis..	D.U.	Willard....	3	80	6	6	18	....	I.R.
Cadillac......	Delco........	S.U.	Exide......	3	120	7	6	18	....	I.R.
Case.........	Westinghouse .	S.U.	Willard....	3	80	6	6	16	....	G.R.
Case.........	Westinghouse .	S.U.	Willard....	3	120	6	6	16	....	G.R.
Chadwick.....	Westinghouse .	D.U.	Willard....	3	80	6	6	20	....	G.R.
Chevrolet.....	Gray & Davis..	.....	Willard....	3	100	6	..	15	....	I.R.
Cole.........	Delco........	S.U.	Exide......	3	80	7	24	21	....	G.R.
Cunningham...	Northeast.....	S.U.	Willard....	8	50	8.5	16	16	....	I.R.
Dorris........	Westinghouse .	D.U.	Willard....	3	80	7	6	15	....	G.R.
Empire.......	Remy........	S.U.	Willard....	6	50	14	12	15	Resist.	G.R.
Fiat..........	Westinghouse .	D.U.	Willard....	3	120	6	6	15	D. Bulb	G.R.
Franklin......	Entz.........	S.U.	Willard....	9	35	7	18	21	....	I.R.
Glide.........	Westinghouse .	D.U.	Willard....	3	80	6	6	16	....	G.R.
Haynes.......	Leece-Nev.....	D.U.	Willard....	6	100	6	12	..	....	I.R.
Hudson.......	Delco........	S.U.	Exide......	12	...	7.2	24	18	....	I.R.
Imperial......	Northeast.....	.....	Willard.....	8	120	8	..	20	....	I.R.
Interstate.....	Aplco........	S.U.	Apple, Mich.	15	100	6	30	18, 20	Series	I.R.
Jeffery.......	U. S. L.......	S.U.	U. S. L.....	12	100	6.7	24	15	....	I.R.
Jackson.......	Auto-Lite.....	D.U.	Willard....	3	100	6	6	15	....	I.R.
King.........	W. Leonard....	D.U.	Willard....	3	80	7.5	6	15	....	I.R.
Kissel........	Esterl.&Kissel .	D.U.	Exide......	6	110	6	12	21	....	I.R.
Kline.........	Rushmore.....	D.U.	Willard....	3	120	6	6	24	....	I.R.
Lenox........	Gray & Davis..	D.U.	Willard....	3	90	6	6	15	....	I.R.

Make of Car	Make of System	Type	Make of Battery	No. of Cells	Capacity Amp. Hrs.	Voltage on Lamps	Voltage on Starter	Headlight C.P.	Type of Dimmer	Wiring System
Lexington	Jesco	S.U.	Willard	8	120	6	6	18	....	I.R.
Little Six	Deaco	S.U.	Willard	3	100	6	6	15	....	I.R.
Locomobile	Adlake	D.U.	Willard	3	120	6–7	5.8	21	....	I.R.
McFarlan	Vesta	.....	Vesta	3	60	7	..	15	....	I.R.
Mercer	Rushmore	D.U.	Willard	3	100	6	6	24	....	G.R.
Mitchell	Esterline	D.U.	Gould	6	120	6	6	12	....	I.R.
Moline	W. Leonard	D.U.	Willard	3	100	6	6	15	D. Bulb	I.R.
Moyer	U. S. L.	S.U.	U. S. L.	12	35	7	24	24	Series	I.R.
Marmon	Northeast	S.U.	Willard	8	50	10	16	24	....	I.R.
National	Gray & Davis	D.U.	Willard	3	100	6	6	15	....	I.R.
Oakland (35)	Deaco	D.U.	Exide	3	...	6	6	12	....	I.R.
Oakland, 42, 60	Delco	S.U.	Exide	12	...	6	6	12	....	I.R.
Olds	Delco	S.U.	Exide	12	160	6–7	24	20	....	I.R.
Overland	U. S. L.	S.U.	U. S. L.	12	80	6	24	16	....	I.R.
Packard 2-48	Bijur	.....	Exide	3	80	7	..	24	....	I.R.
Packard 1-38	Delco	S.U.	Willard	3	100	7	7	24	....	I.R.
Paige-Detroit	Gray & Davis	D.U.	Willard	3	90	7	6	15	....	I.R.
Paterson	Auto-Lite	D.U.	Willard	3	80	6	6	12	....	I.R.
Pathfinder	Gray & Davis	D.U.	Willard	3	80	6	6	15	....	G.R.
Peerless	Gray & Davis	D.U.	Willard	3	120	6–7	6	15	....	I.R.
Pierce-Arrow	Westinghouse	D.U.	Exide	3	...	6	..	21	Resist.	G.R.
Pilot	Gray & Davis	D.U.	Willard	3	80	6	6	15	Resist.	G.R.
Reo	Gray & Davis	D.U.	Willard	3	100	6.5	6	15	....	I.R.
Republic	Delco	S.U.	Exide	3	...	6	6	16	D. Bulb	I.R.
Simplex	Rushmore	D.U.	Willard	3	120	6–7	6	40	....	G.R.
Spaulding	Gray & Davis	D.U.	Willard	3	100	6	6	21	....	I.R.
Stearns	Gray & Davis	D.U.	Willard	3	80	6	6	15	....	I.R.
Studebaker	Wagner	S.U.	Willard	6	50	7	12	15	....	I.R.
Stutz	Esterline	S.U.	Willard	3	80	6	6	21	....	I.R.
Velie	Gray & Davis	D.U.	Willard	3	80	6	6	15	....	I.R.
Westcott	Jesco	S.U.	Willard	8	35	8	16	21	Series	I.R.
White	White	S.U.	Exide	9	35	7	21	21	....	I.R.
White	White	S.U.	Willard	9	60	7	21	21	....	I.R.
YEAR 1914										
Allen	Auto-Lite	D.U.	Willard	3	100	6	6	15	....	I.R.
Apperson	Bijur	D.U.	Willard	3	80	6	6	18	Series	I.R.
Glide	Westinghouse	D.U.	Willard	3	80	6	6	16	Series	G.R.
Auburn	Remy	S.U.	Willard	3	120	6	6	15	D. Bulb	I.R.
Briscoe	Aplco	S.U.	Willard	6	60	14	..	18	D. Bulb	G.R.
Buick	Delco	S.U.	Exide	3	80	6	6	..	....	G.R.
Cadillac	Delco	S.U.	Exide	3	130	7	6	18	....	G.R.
Case	Westinghouse	S.U.	Willard	3	80	6	6	16	....	G.R.
Case	Westinghouse	S.U.	Willard	3	100	6	6	16	....	G.R.
Case	Westinghouse	S.U.	Willard	3	120	6	6	16	....	G.R.
Chadwick	Westinghouse	D.U.	Willard	3	100	6	6	20	D. Bulb	G.R.
Chalmers	Entz	S.U.	U. S. L.	9	50	7	18	24	D. Bulb	I.R.
Chalmers	Entz	S.U.	U. S. L.	9	50	21	18	21	D. Bulb	I.R.
Chandler	Westinghouse	S.U.	Willard	3	80	6	6	18	D. Bulb	G.R.
Chevrolet	Gray & Davis	S.U.	Willard	3	100	6	6	15	....	I.R.

Make of Car	Make of System	Type	Make of Battery	No. of Cells	Capacity Amp. Hrs.	Voltage on Lamps	Voltage on Starter	Headlight C.P.	Type of Dimmer	Wiring System
Chevrolet	Auto-Lite	S.U.	Willard	3	80	6	6	15	....	I.R.
Cole	Delco	S.U.	Exide	3	120	7	6	21	....	G.R.
Dorris	Westinghouse	D.U.	Willard	3	80	7	6	15	....	G.R.
Empire	Remy	S.U.	Willard	6	50	14	12	15	....	G.R.
Fiat	Westinghouse	D.U.	Willard	3	120	6	6	15	....	G.R.
Franklin	Entz	S.U.	....	9	35	21	18	21	Resist.	I.R.
Grant	Allis-Chalmers	S.U.	Wright	3	60	6	6	12	Resist.	G.R.
Haynes	Leece-Nev	D.U.	Willard	6	72	6	12	..	....	I.R.
Hudson	Delco	S.U.	Exide	3	80	7.2	6	15	Resist.	G.R.
Hupp	Westinghouse	D.U.	Willard	3	100	6–7	6	15	Resist.	G.R.
Imperial	Northeast	S.U.	Willard	8	120	8	..	20	D. Bulb	I.R.
Jeffery-4	U. S. L.	S.U.	U. S. L.	6	100	6–7	12	18	Resist.	I.R.
Jeffery-6	U. S. L.	S.U.	U. S. L.	12	100	6–7	24	18	Resist.	I.R.
King	W. Leonard	D.U.	Willard	3	80	7.5	6	15	D. Bulb	I.R.
Kissel	Esterl. & Kissel	D.U.	Exide	6	110	6	12	21	....	I.R.
Kline	Rushmore	D.U.	Willard	3	120	6	6	24	....	I.R.
Lenox	Gray & Davis.	D.U.	Willard	3	90	6	6	15	....	I.R.
Lexington	Jesco	S.U.	Willard	3	100	6	6	16.	Resist.	G.R.
Locomobile	Gray & Davis	D.U.	Willard	3	120	6–7	5.8	21	....	I.R.
Lozier	Gray & Davis	D.U.	Willard	3	80	6	6	18	Series	.....
L. P. C	Remy	D.U.	Willard	3	100	6	6	15	D. Bulb	G.R.
Lyons-Atl	Northeast	S.U.	Willard	12	30	6	24	24	Resist.	I.R.
McFarlan	Deaco	.....	Vesta	3	80	7	..	15	D. Bulb	I.R.
Marmon	Northeast	S.U.	Willard	8	50	10	16	24	....	I.R.
Mason	Jesco	S.U.	Willard	3	120	6	6	15	Resist.	I.R.
Maxwell	Gray & Davis	D.U.	Willard	3	80	6	6	12	....	I.R.
Mercer	Rushmore	D.U.	Willard	3	100	6	6	24	....	G.R.
Metz	Northeast	S.U.	Willard	..	...	..	..	..	....	.....
Mitchell	Remy	D.U.	Willard	6	120	6	6	12	....	I.R.
Moline	Wagner	D.U.	Willard	6	60	6	12	15	....	I.R.
National	Deaco	S.U.	Willard	3	80	6	6	15	D. Bulb	I.R.
Oakland	Delco	S.U.	Exide	3	...	7	7	12–18	....	I.R.
Olds	Delco	S.U.	Exixe	3	160	6–7	6	20	....	G.R.
Packard 3-48	Delco	D.U.	Willard	3	100	7	7	24	....	I.R.
Packard 2-38	Bijur	D.U.	Willard	3	120	7	7	29	....	I.R.
Packard 4-48	Bijur	D.U.	Willard	3	120	7	7	29	....	I.R.
Paige	Gray & Davis	D.U.	Willard	3	90	7	6	15	D. Bulb	G.R.
Paterson	Delco	S.U.	Exide	3	120	6	6	12	....	I.R.
Pathfinder-4	Gray & Davis	D.U.	Willard	3	80	6	6	15	....	G.R.
Pathfinder-6	Deaco	S.U.	Willard	3	80	6	6	15	D. Bulb	G.R.
Peerless	Gray & Davis	D.U.	Willard	3	120	6–7	6	15	....	I.R.
Pierce-Arrow	Westinghouse	D.U.	Exide	3	93	6	6	21	Resist.	G.R.
Pilot	Gray & Davis	D.U.	Willard	3	80	6	6	15	Resist.	G.R.
Reo	Natl. & Remy	D.U.	Willard	3	100	6.5	6	15	Series	I.R.
Republic	Delco	S.U.	Exide	3	...	6	6	16	D. Bulb	I.R.
Simplex	Rushmore	D.U.	Willard	3	120	6–7	6	40	....	G.R.
Spaulding	Entz	S.U.	Willard	9	50	18	18	15	D. Bulb	I.R.
Stearns	Gray & Davis	D.U.	Willard	3	80	6	6	15	....	G.R.
Studebaker	Wagner	D.U.	Willard	3	100	7	6	15	....	I.R.
Stutz	Remy	S.U.	Willard	3	120	7	7	21	....	I.R.
Velie	Gray & Davis	D.U.	Willard	3	80	6	6	15	....	G.R.

Make of Car	Make of System	Type	Make of Battery	No. of Cells	Capacity Amp. Hrs.	Voltage on Lamps	Voltage on Starter	Head-light C.P.	Type of Dimmer	Wiring System
Westcott	Jesco	S.U.	Willard	3	80	7	6	15	D. Bulb	G.R.
White	White	S.U.	....	9	35	7	21	21	....	I.R.
White	White	S.U.	....	9	69	7	21	21	....	I.R.
Overland	Gray & Davis	D.U.	Willard	3	80	6	6	16	....	I.R.
Winton	Gray & Davis	.....	Willard	3	80	6	..	15	....	G.R.

YEAR 1915

Make of Car	Make of System	Type	Make of Battery	No. of Cells	Capacity Amp. Hrs.	Voltage on Lamps	Voltage on Starter	Head-light C.P.	Type of Dimmer	Wiring System
Allen	Westinghouse	D.U.	Willard	3	80	7	6	15	Resist.	G.R.
Apperson	Bijur	D.U.	Willard	3	80	6	6	18	Series	I.R.
Auburn 6	Delco	S.U.	Exide	3	100	6	6	15	....	G.R.
Auburn 4	Remy	D.U.	Willard	3	80	6	6	15	....	G.R.
Briscoe	Aplco	S.U.	Willard	6	60	14	..	18	D. Bulb	G.R.
Buick	Delco	S.U.	Exide	3	80	6	6	16–21	....	G.R.
Cadillac	Delco	S.U.	Exide	3	130	7	6	18	....	G.R.
Case	Westinghouse	S.U.	Willard	3	80	6	6	16	D. Bulb	G.R.
Chadwick	Westinghouse	D.U.	Willard	3	100	6	6	20	D. Bulb	G.R.
Chalmers	Entz	S.U.	U. S. L.	9	50	21	18	21	Series	I.R.
Chalmers 32	Gray & Davis	D.U.	Willard	3	80	7	6	15	D. Bulb	G.R.
Chandler	Gray & Davis	D.U.	Willard	3	80	7	6	18	D. Bulb	G.R.
Chevrolet C	Gray & Davis	S.U.	Willard	3	100	6	6	15	....	I.R.
Chevrolet 6	Auto-Lite	S.U.	Willard	3	80	6	6	15	....	I.R.
Chevrolet H	Auto-Lite	S.U.	Willard	3	80	6	6	18	D Bulb	G.R.
Cole	Delco	S.U.	Exide	3	120	7	6	21	Resist.	G.R.
Cunningham	Westinghouse	D.U.	Willard	3	120	7	6	15	....	G.R.
Detroiter	Dyneto	S.U.	G. L. B.	7	35	12	12	21	Resist.	G.R.
Dodge	Northeast	S.U.	Willard	6	42	14	12	15	Resist.	I.R.
Dorris	Westinghouse	D.U.	Willard	3	100	7	6	15	....	G.R.
Empire	Remy	S.U.	Willard	6	50	14	12	15	D. Bulb	G.R.
Fiat	Rushmore	D.U.	U. S. L.	3	120	6	6	15	D. Bulb	G.R.
Franklin	Dyneto	S.U.	Willard	6	60	14	12	21	D. Bulb	I.R.
Glide	Westinghouse	D.U.	Willard	3	80	6	6	16	D. Bulb	G.R.
Grant	Allis-Chalmers	S.U.	Wright	3	80	6	6	15	Series	G.R.
Haynes	Leece-Nev.	S.U.	Willard	3	100	6	6	..	Series	I.R.
Hudson	Delco	S.U.	Exide	3	...	7.2	7.2	15	Resist.	G.R.
Hupmobile	Westinghouse	S.U.	Willard	6	50	14	12	15	Resist.	G.R.
Interstate	Remy	D.U.	Willard	3	80	6	6	16	Resist.	G.R.
Jeffery	Bijur	D.U.	Willard	3	100	6.4	6	12–18	Series	G.R.
Jackson	Auto-Lite	D.U.	Willard	3	100	6	6	15	D. Bulb	I.R.
Kearns	Allis-Chalmers	S.U.	Miller	..	...	6	6	10	....	.....
King	W. Leonard	D.U.	Willard	3	80	7.5	6	15	D. Bulb	I.R.
Kissel	West. & Kissel	D.U.	Willard	3	100	6	6	18–21	Series	G.R.
Kline	Westinghouse	D.U.	Willard	3	120	6	6	18	D. Bulb	I.R.
Lenox	Westinghouse	.....	Exide	3	100	6	6	15	....	G.R.
Lexington	Westinghouse	D.U.	Willard	3	100	6	6	16	Resist.	G.R.
Locomobile	Westinghouse	D.U.	Willard	3	120	6–7	5.8	21	....	G.R.
Lozier	Gray & Davis	D.U.	Willard	3	80	6	6	18–21	Series	.....
L. P. C	Remy	D.U.	Willard	3	100	6	6	15	D. Bulb	G.R.
Lyons-Atl	Northeast	S.U.	Willard	12	30	6	24	24	Resist.	I.R.
McFarlan	Westinghouse	D.U.	Willard	3	120	7	6	21	D. Bulb	G.R.
Madison	Remy	D.U.	Willard	3	80	6	6	15	D. Bulb	G.R.

Make of Car	Make of System	Type	Make of Battery	No. of Cells	Capacity Amp. Hrs.	Voltage on Lamps	Voltage on Starter	Head-light C.P.	Type of Dimmer	Wiring System
Marion	Westinghouse	S.U.	Willard	3	120	6	6	15	....	G.R.
Marmon	Bosch	D.U.	Willard	6	60	12	12	25	....	G.R.
Mason	Westinghouse	D.U.	Willard	3	80	6	6	18	....	I.R.
Maxwell	Simms-Huff	S.U.	Presto	6	35	6	6	12	Resist.	G.R.
Mercer	U. S. L.	S.U.	U. S. L.	6	100	12	12	18	D. Bulb	G.R.
Metz	Gray & Davis	D.U.	Willard	3	60	6	6	15	....	I.R.
Mitchell	Aplco	S.U.	Willard	6	120	7	12	15	Series	I.R.
Moline	Auto-Lite	D.U.	Willard	3	100	6	6	15	D. Bulb	G.R.
National	Westinghouse	D.U.	Willard	3	100	6	6	15	D. Bulb	I.R.
Oakland	Delco	S.U.	Exide	3	...	7	7	16	Series	G.R.
Olds	Delco	S.U.	Exide	3	120	6–7	6	18–20	Resist.	G.R.
Overland	Auto-Lite	D.U.	U. S. L. Will	3	80	6	6	16	....	G.R.
Packard	Bijur	D.U.	Willard	3	120	7	7	24	....	I.R.
Paige	Gray & Davis	D.U.	Willard	3	90	7	6	15	D. Bulb	G.R.
Paterson	Delco	S.U.	Exide	3	120	6	6	16	Resist.	G.R.
Pathfinder	Westinghouse	D.U.	Willard	3	120	6	6	15	D. Bulb	G.R.
Peerless	Gray & Davis	D.U.	Willard	3	80,120	6–7	6	15	....	G.R.
Pierce-Arrow	Westinghouse	D.U.	Exide	3	113	6–7	6	21	Resist.	G.R.
Pilot	Westinghouse	D.U.	Willard	3	100	6	6	15	Resist.	G.R.
Regal	Dyneto	S.U.	....	6	35	12	12	21	Series	G.R.
Regal	Rushmore	D.U.	....	3	80	6	6	21	Series	G.R.
Reo	Natl. & Remy	D.U.	Willard	3	100	6.5	6	15	Series	I.R.
Republic	Delco	S.U.	Exide	3	...	6	6	15	D. Bulb	I.R.
Simplex-Crane	Rushmore	D.U.	Willard	3	120	7	7	40	....	G.R.
Spaulding	Entz	S.U.	Willard	9	50	18	18	15	D. Bulb	I.R.
Stearns	Gray & Davis	D.U.	Willard	6	80	6	12	12	D. Bulb	G.R.
Studebaker	Wagner	D.U.	Willard	3	100	7	6	15	Series	I.R.
Stutz	Remy	S.U.	Willard	3	120	7	7	21	....	I.R.
Velie	Gray & Davis	D.U.	Willard	3	80	6	6	15	....	G.R.
Westcott	Delco	S.U.	Exide	3	80	7	6	15	Resist.	G.R.
White	White	S.U.	....	9	35, 60	21	21	21	D. Bulb	I.R.
Winton	G. & D., Bijur	D.U.	Willard	3	120	6	6	15	....	G.R.

YEAR 1916

Make of Car	Make of System	Type	Make of Battery	No. of Cells	Capacity Amp. Hrs.	Voltage on Lamps	Voltage on Starter	Head-light C.P.	Type of Dimmer	Wiring System
Allen	Westinghouse	D.U.	Gould	3	80	7	6	15	Resist.	G.R.
Apperson	Bijur	D.U.	Willard	3	80	6	6	18	Series	I.R.
Auburn-40	Delco	S.U.	Willard	3	80	6	6	15	D. Bulb	G.R.
Auburn-38	Remy	D.U.	Willard	3	60	6	6	15	D. Bulb	G.R.
Briscoe	Aplco	S.U.	Willard	3	60	7	7	15	D. Bulb	G.R.
Buick	Delco	S.U.	Exide	3	80,100	6	6	16–21	Resist.	G.R.
Cadillac	Delco	S.U.	Exide	3	130	8	6	18	....	G.R.
Case	Westinghouse	S.U.	Exide	3	80	7.5	6	18	D. Bulb	G.R.
Chadwick	Westinghouse	D.U.	Willard	3	100	6	6	20	D. Bulb	G.R.
Chalmers	Entz	S.U.	U. S. L.	9	50	21	18	21	Series	I.R.
Chalmers 32	Gray & Davis	D.U.	Willard	3	80	7	6	15	D. Bulb	G.R.
Chandler	Gray & Davis	D.U.	Willard	3	80	7	6	18	D. Bulb	G.R.
Chevrolet	Auto-Lite	S.U.	Willard	3	80	6	6	18	D. Bulb	G.R.
Crow	Disco	S.U.	Detroit	6	35	12	12	15	D. Bulb	G.R.
Dorris	Westinghouse	D.U.	Willard	3	100	7	6	15	Resist.	G.R.

Make of Car	Make of System	Type	Make of Battery	No. of Cells	Capacity Amp. Hrs.	Voltage on Lamps	Starter	Head-light C.P.	Type of Dimmer	Wiring System
Empire	Auto-Lite	D.U.	Willard	3	80	7	6	15	D. Bulb	G.R.
Fiat	Rushmore	D.U.	U. S. L.	3	120	6	6	15	D. Bulb	G.R.
Franklin	Dyneto	S.U.	Willard	6	60	14	12	21	D. Bulb	I.R.
Glide	Westinghouse	D.U.	Presto	3	80	6	6	16	D. Bulb	G.R.
Grant	Allis Chalmers	S.U.	Wright	3	80	6	6	15	Series	G.R.
Haynes	Leece-Nev.	S.U.	Willard	3	100	6	6	..	Series	G.R.
Hudson	Delco	S.U.	Exide	3	80	7.2	7.2	15	Resist.	G.R.
Hupp	Bijur	D.U.	Willard	3	60	7–8	6	15	Resist.	G.R.
Interstate	Remy	D.U.	Willard	3	80	6	6	16	Resist.	G.R.
Jackson	Auto-Lite	D.U.	Willard	3	100	6	6	15	Series	G.R.
Jeffery	Bijur	D.U.	U. S. L.	3	80	7.5	6	18	D. Bulb	G.R.
Kearns	Disco	S.U.	Pumpelly	6	40	12	12	10	....	.....
Kissel	West. & Kissel	D.U.	Willard	3	108	7	6	18	Series	G.R.
Lenox	Westinghouse	D.U.	Exide	3	100	6	6	15	....	G.R.
Lexington	Westinghouse	D.U.	Willard	3	100	6	6	16	D. Bulb	G.R.
Locomobile	Westinghouse	D.U.	Willard	3	120	6–7	5.8	21	....	G.R.
Lozier	Gray & Davis	D.U.	Willard	3	80	6	6	18–21	Series	.....
L. P. C.	Remy	S.U.	Willard	6	100	12–14	12	15	D. Bulb	G.R.
McFarlan	Westinghouse	D.U.	Gould	3	120	7	6	21	D. Bulb	G.R.
Marion	Westinghouse	S.U.	Willard	3	120	6	6	55	....	G.R.
Marmon	Bosch	D.U.	Willard	6	60	12	12	25	....	G.R.
Maxwell	Simms-Huff	S.U.	Presto	6	35	7	6	12	Resist.	G.R.
Mercer	U. S. L.	S.U.	U. S. L.	6	100	12	12	18	D. Bulb	G.R.
Metz	Gray & Davis	D.U.	Willard	3	60	6	6	15	....	I.R.
Mitchell-6	Aplco	S.U.	Willard	6	120	7	12	15	Series	I.R.
Mitchell-8	Westinghouse	D.U.	Willard	3	120	7	6	15	Series	G.R.
National	Westinghouse	D.U.	Willard	3	95	6	6	15	D. Bulb	I.R.
Oakland-32	Remy	D.U.	Willard	3	...	7	7	12	Series	G.R.
Oakland-38, 50	Delco	S.U.	Exide	3	...	7	7	12	Series	G.R.
Olds	Delco	S.U.	Exide	3	80	6–7	6	18	Resist.	G.R.
Overland	Auto-Lite	D.U.	Willard	3	80, 120	6	6	16	Series	G.R.
Packard	Bijur	D.U.	Willard	3	120	7	7	24	....	I.R.
Paige	Gray & Davis	D.U.	Willard	3	90	7	6	15	D. Bulb	G.R.
Paterson	Delco	D.U.	Willard	3	80	6	6	16	D. Bulb	G.R.
Pathfinder	Westinghouse	D.U.	Willard	3	60	6	6	15	D. Bulb	G.R.
Peerless	Gray & Davis	D.U.	Willard	3	80	6–7	6	15	....	G.R.
Pierce-Arrow	Westinghouse	D.U.	Exide	3	135	6–7	6	21	Resist.	G.R.
Pilot	Westinghouse	D.U.	Willard	3	100	6	6	15	Resist.	G.R.
Pilot	Delco	S.U.	Willard	3	100	6	6	15	Resist.	G.R.
Regal	Dyneto	S.U.	Gould, U.S.L.	6	35, 50	12	12	21	Series	G.R.
Reo	Remy	D.U.	Willard	3	100	7	6	17	Series	I.R.
Republic	Delco	S.U.	Exide	3	...	6	6	16	D. Bulb	I.R.
Simplex-Crane	Rushmore	D.U.	Gould	3	120	7	7	40	D. Bulb	G.R.
Spaulding	Entz	S.U.	Willard	9	50	18	18	15	D. Bulb	I.R.
Stearns	Westinghouse	D.U.	Willard	6	80	12	12	18	D. Bulb	G.R.
Studebaker	Wagner	D.U.	Willard	3	100	7	6	15	Resist.	G.R.
Stutz	Remy	S.U.	Willard	3	120	7	7	21	D. Bulb	I.R.
Velie	Gray & Davis	D.U.	Willard	3	80	6	6	15	....	G.R.
Westcott	Delco	S.U.	Willard	3	100	7	6	15	D. Bulb	G.R.
White	White	S.U.	Exide	9	35, 60	21	21	21	D. Bulb	I.R.
Winton	Bijur	D.U.	Willard	3	120	6	6	15	....	G.R.

CHAPTER V

TYPICAL STARTING AND LIGHTING SYSTEMS

Delco—Dyneto-Entz—Auto-Lite—Gray & Davis—North East—Bijur—Simms-Huff—Genemotor—One Unit Ford System—Bosch-Rushmore—Remy—Westinghouse.

Delco Systems.—The various components of the Delco ignition system have been outlined in the preceding chapter on ignition. A wiring diagram of the 1914 Delco-Olds system is shown at the top of Fig. 168 for those with a sufficient knowledge of electricity to be able to trace the various wires. All of the units are shown in diagram form, but the operation of the system may be easily understood if this is studied in connection with the diagram at Fig. 169. The ignition system will draw its current either from a five-cell dry battery or from the storage battery. The function of the ignition relay has been previously described. It will be observed that this system operates on the one wire method, all connections for return of current to the storage battery and the various units being made by the motor car frame. The broken lines indicate a ground connection, while the full lines designate wires. Considering the starting connections first, it will be apparent that one of the terminals of the storage battery is grounded to the frame, whereas the other is joined to one of the terminals of the starting switch. The other terminal of the starting switch is joined to the windings of the motor generator, which makes that device act as a motor to turn the engine crankshaft. The return from the motor windings to the storage battery is by means of a grounded return wire. With the switch in the position shown, the starting windings are not connected with the storage battery, but the generator windings are. One of the generator terminals is joined di-

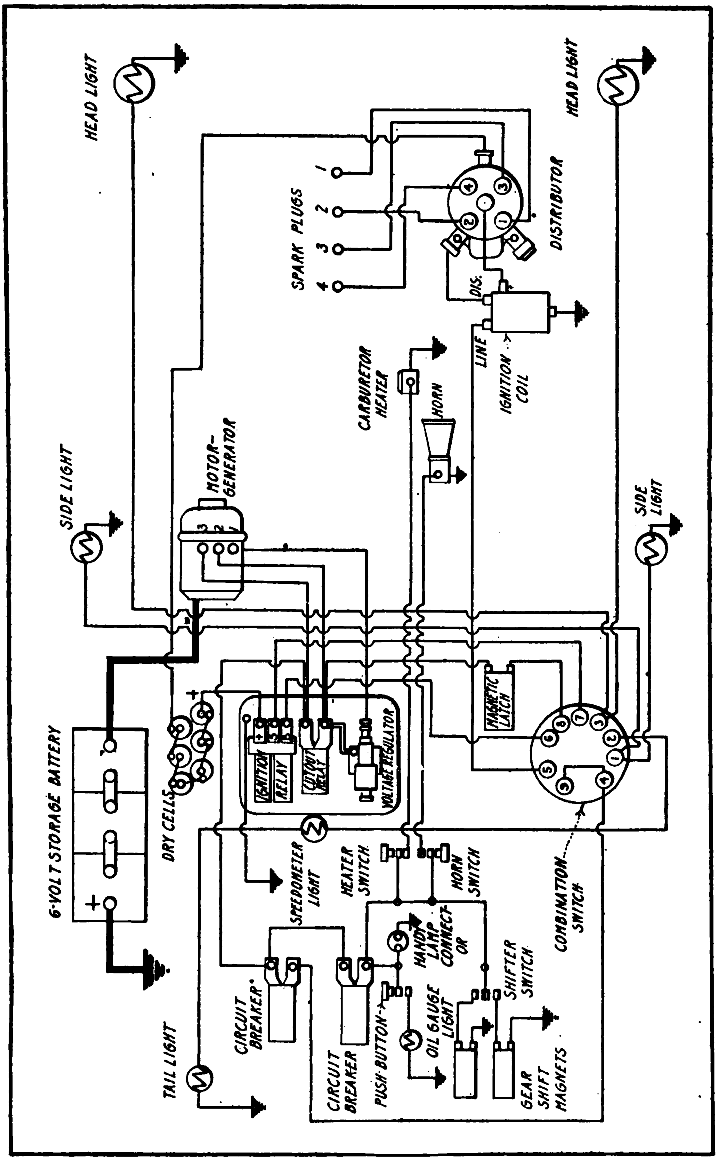


Fig. 169.—The 1914 Delco-Cadillac Starting, Lighting and Ignition System Using Voltage Regulator.

rectly to the frame. The other passes through the cutout relay and through the voltage regulator, both of which have been previously described. Six of the terminals on the distributor head, which are for ignition, are joined to the spark plugs. The remaining terminal, which is in the center of the group, is joined to the secondary terminal of the ignition coil. The circuit through the secondary is completed through a grounding wire, which is in electrical contact with the grounded bodies of the spark plugs. The insulated terminals of the spark plugs are joined to the six terminals on the distributor head. The primary winding of the ignition coil is joined to the circuit breaker through one terminal, this in turn passing through the dry battery to the ignition relay. The other terminal of the ignition coil is joined to the starting, lighting and ignition switch by a suitable conductor.

The arrangement of this switch is such that the current may be supplied directly to the head, side and tail lamps from the storage battery at all times that the switch circuit is closed. It is also possible to draw the ignition current either from the six-volt storage battery or from the battery of dry cells. The only time that the storage battery current flows through the starting motor windings is when the starting switch closes the circuit between the storage battery and the motor. At all other times the starting switch member is in such a position that the generator windings are in action and that the current from the armature is being passed into the storage battery.

Delco Motor Generator.—The motor generator which is located on the right side of the engine as at Fig. 170 is the principal part of the Delco System. This consists essentially of a dynamo with two field windings, and two windings on the armature with two commutators and corresponding sets of brushes, in order that the ignition apparatus incorporated in the forward end of the machine may work both as a starting motor, and as a generator for charging the battery and supplying the lights, horn and ignition. The ignition apparatus is incorporated in the forward end of the motor generator. This in no way affects the working of the generator, it being mounted in this manner simply as a convenient and accessible mounting.

The motor generator has three distinct functions to perform which are as follows: No. 1—Motoring the Generator. No. 2—Cranking the Engine. No. 3—Generating Electrical Energy.

Motoring the Generator.—Motoring the generator is accomplished when the ignition button on the switch is pulled out. This allows current to come from the storage battery through the ammeter on the combination switch, causing it to show a discharge.

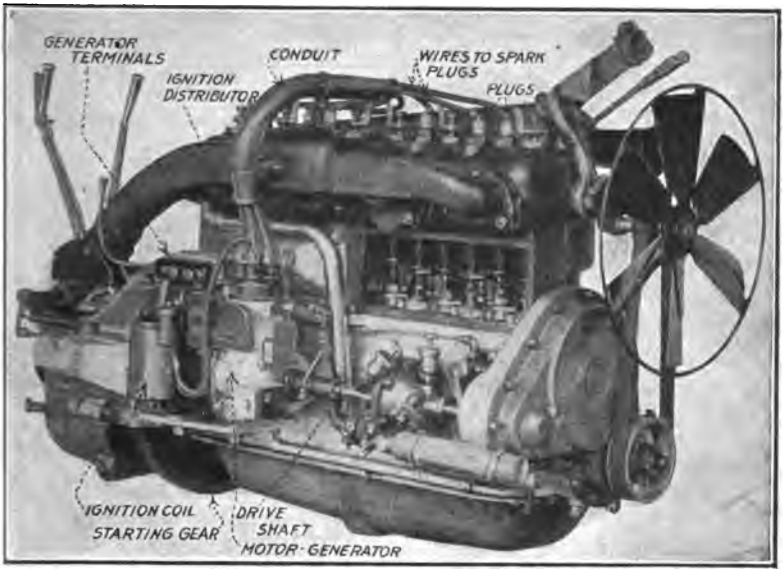


Fig. 170.—Application of Delco Motor Generator to 1916 Hudson Engine.

The first reading of the meter will be much more than the reading after the armature is turning freely. The current discharging through the ammeter during this operation is the current required to slowly revolve the armature and what is used for the ignition. The ignition current flows only when the contacts are closed, it being an intermittent current. The maximum ignition current is obtained when the circuit is first closed and the resistance unit on the rear end of the coil is cold. The current at this time is approximately

6 amperes, but soon decreases to approximately 3½ amperes. Then as the engine is running it further decreases until at 1,000 revolutions of the engine it is approximately 1 ampere.

This motoring of the generator is necessary in order that the starting gears may be brought into mesh, and should trouble be experienced in meshing these gears, do not try to force them, simply

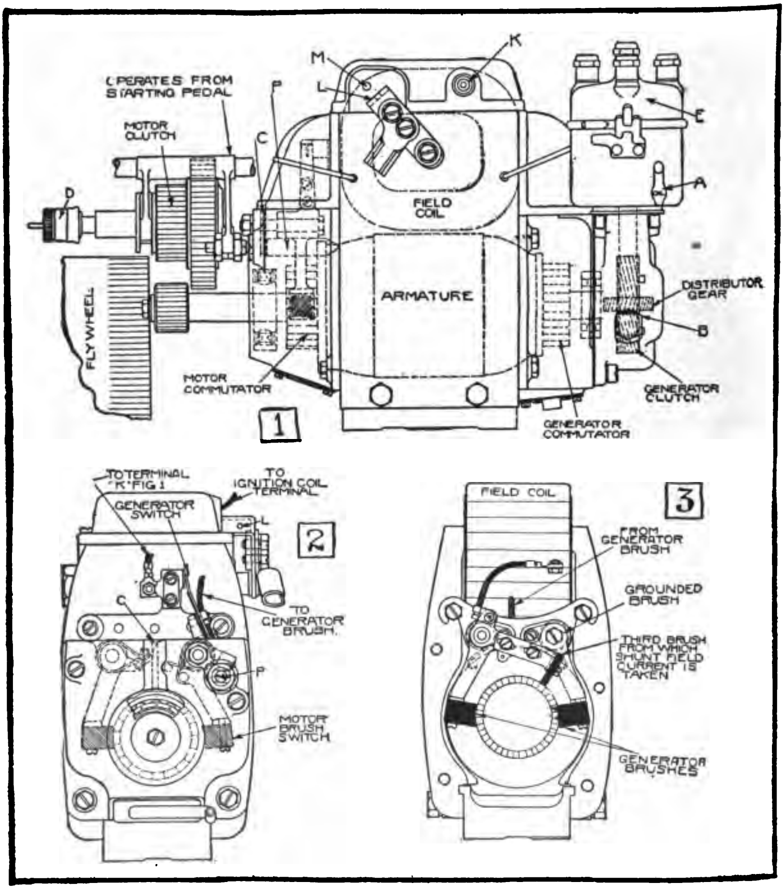


Fig. 171.—Diagrams Explaining Construction of Delco Motor Generator Having Third Brush Current Control.

allow the starting pedal to come back, giving the gears time to change their relative position.

Generator Clutch.—A clicking sound will be heard during the motoring of the generator. This is caused by the overrunning of the clutch in the forward end of the generator which is shown in view 1, Fig. 171.

The purpose of the generator clutch is to allow the armature to revolve at a higher speed than the pump shaft during the cranking operation and permitting the pump shaft to drive the armature

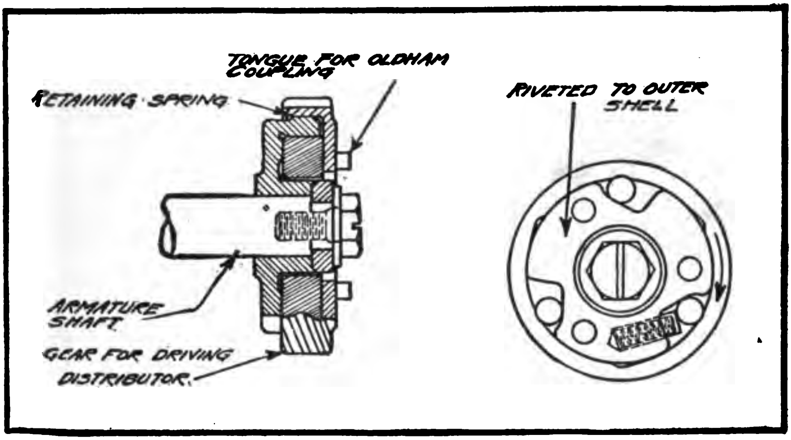


Fig. 172.—The Delco Overrunning Clutch.

when the engine is running on its own power. A spiral gear is cut on the outer face of this clutch for driving the distributor. This portion of the clutch is connected by an Oldham coupling to the pump shaft. Therefore, its relation to the pump shaft is always the same and does not throw the ignition out of time during the cranking operation. This clutch receives lubrication from the oil that is contained in the front end of the generator which is put in at B (view 1). This is to receive oil each week sufficient to bring the oil up to the level of the oiler. The arrangement of clutch parts is shown at Fig. 172.

Cranking Operation.—The cranking operation takes place when the starting pedal is fully depressed. The starting pedal brings the

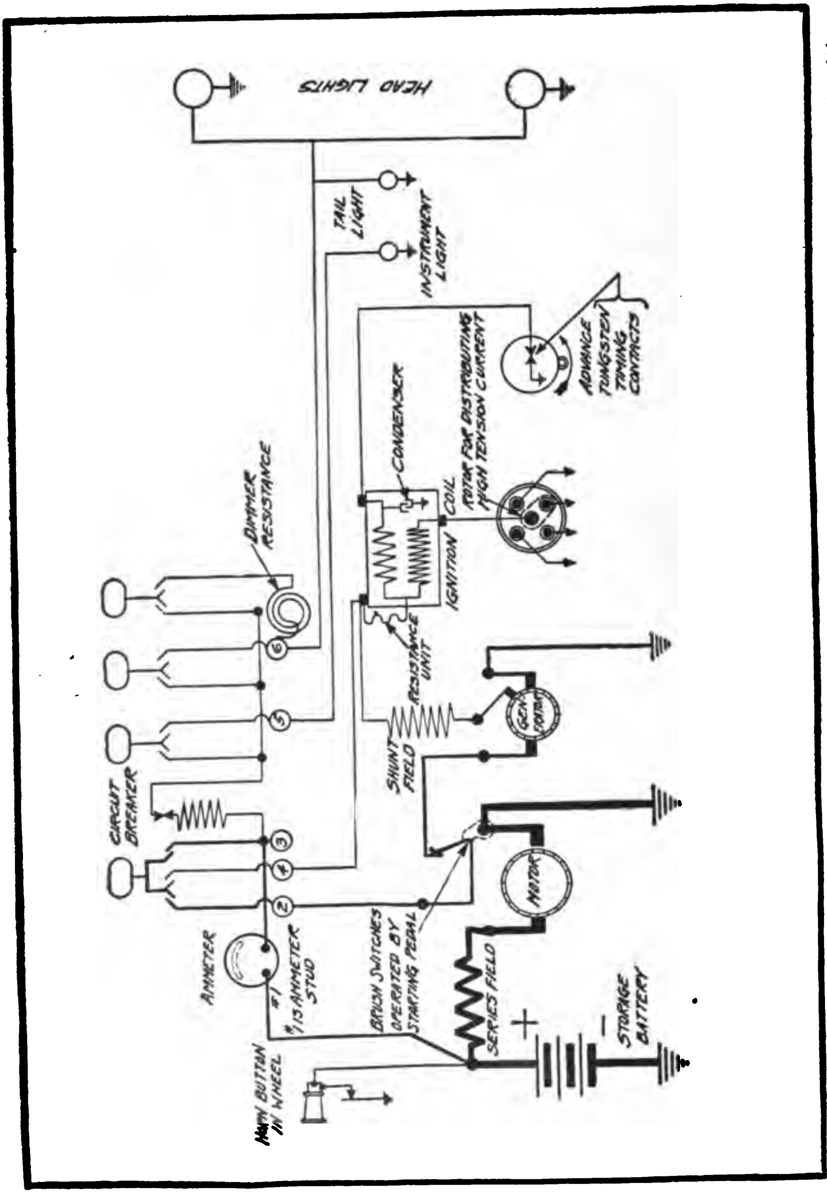


Fig. 173.—Wiring Diagram Showing Relation of Parts of 1916 Oakland-Delco Starting, Lighting and Ignition System

motor clutch gears (view 1) into mesh and withdraws the pin P, (views 1 and 2) allowing the motor brush switch to make contact on the motor commutator. At the same time the generator switch breaks contact. This cuts out the generator element during the cranking operation. As soon as the motor brush makes contact on the commutator a heavy current from the storage battery flows through the series field winding and the motor winding on the armature. This rotates the armature and performs the cranking operation. The cranking circuit is shown in the heavy lines on the circuit diagram (Fig. 173). This cranking operation requires a heavy current from the storage battery, and if the lights are on during the cranking operation, the heavy discharge from the battery causes the voltage of the battery to decrease enough to cause the lights to grow dim. This is noticed especially when the battery is nearly discharged; also will be more apparent with a stiff motor or with a loose or poor connection in the battery circuit or a nearly discharged battery. It is on account of this heavy discharge current that the cranking should not be continued any longer than is necessary, although a fully charged battery will crank the engine for several minutes.

During the cranking operation the ammeter will show a discharge. This is the current that is used both in the shunt field winding and the ignition current; the ignition current being an intermittent current of comparatively low frequency will cause the ammeter to vibrate during the cranking operation. If the lights are on the meter will show a heavier discharge. The main cranking current is not conducted through the ammeter, as this is a very heavy current and it would be impossible to conduct this heavy current through the ammeter and still have an ammeter that is sensitive enough to indicate accurately the charging current and the current for lights and ignition. As soon as the engine fires the starting pedal should be released immediately, as the overrunning motor clutch is operating from the time the engine fires until the starting gears are out of mesh. Since they operate at a very high speed, if they are held in mesh for any length of time, there is enough friction in this clutch to cause it to heat and burn out the lubricant. There is no necessity for holding the gears in mesh.

Motor Clutch.—The motor clutch operates between the flywheel and the armature pinion for the purpose of getting a suitable gear reduction between the motor generator and the flywheel. It also prevents the armature from being driven at an excessively high speed during the short time the gears are meshed after the engine is running on its own power. This clutch is lubricated by the grease cup A, shown in view 1, Fig. 171. This forces grease through the hollow shaft to the inside of the clutch. This cup should be given a turn or two every week.

Generating Electrical Energy.—When the cranking operation is finished the motor brush switch is raised off the commutator by the pin P when the starting pedal is released. This throws the starting motor out of action. As the motor brush is raised off the commutator the generator switch makes contact and completes the charging circuit. The armature is then driven by the extension of the pump shaft and the charging begins. At speeds above approximately 7 miles per hour the generator voltage is higher than the voltage of the storage battery which causes current to flow from the generator winding through the armature in the proper direction to charge the storage battery. As the speed increases up to approximately 20 miles per hour this charging current increases, but at the higher speeds the charging current decreases. The curve, Fig. 173, shows approximately the charging current that should be received for different speeds of the car. There will be slight variations from this due to temperature changes and conditions of the battery which will amount to as much as from 2 to 3 amperes.

Lubrication.—There are five places to lubricate this Delco System. No. 1—The grease cup for lubricating the motor clutch (D, view 1, Fig. 171). No. 2—Oiler for lubricating the generator clutch and forward armature bearing (B). No. 3—The oil hole (C) for lubricating the bearings on the rear of the armature shaft. This is exposed when the rear end cover is removed. This should receive oil once a week. No. 4—The oil hole in the distributor, at A, for lubricating the top bearing of the distributor shaft. This should receive oil once a week. No. 5—This is the inside of the distributor head. This should be lubricated with a small amount

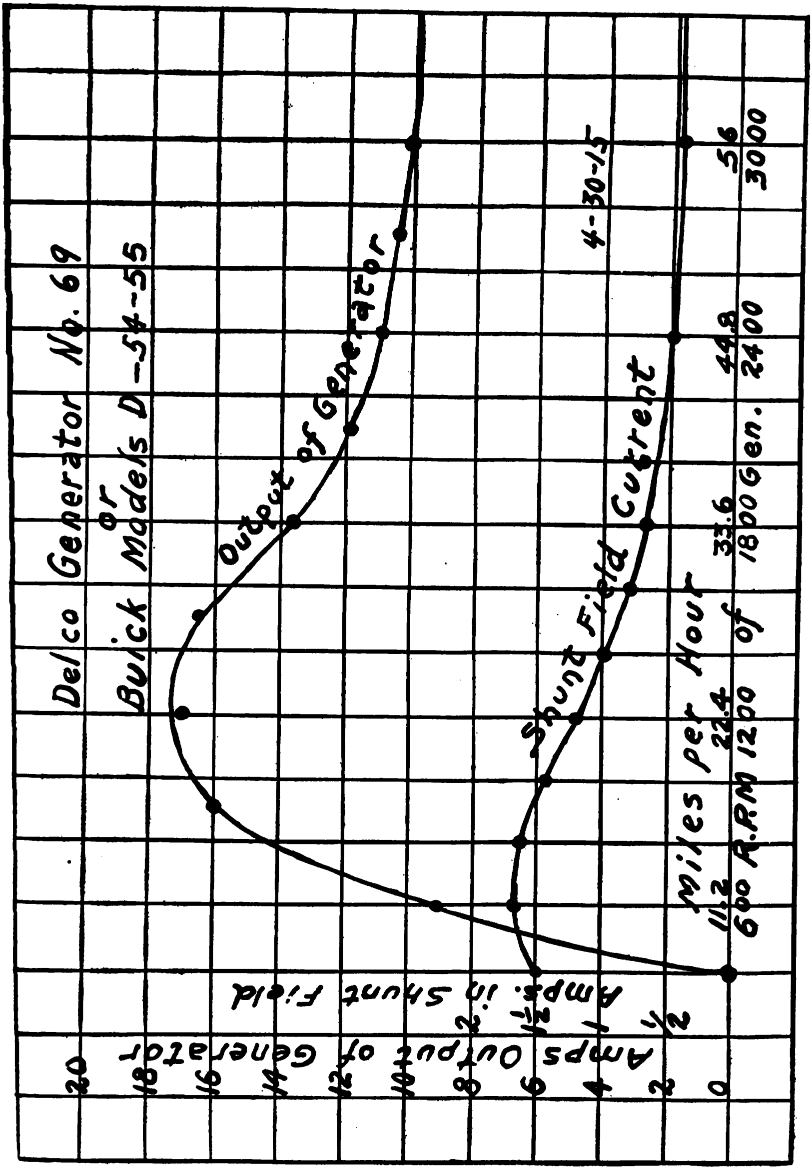


Fig. 174.—Curves Showing Output of Delco Generator No. 69 at Different Car Speeds.

of vaseline, carefully applied two or three times during the first 2,000 miles running of the car, after which it will require no attention. This is to secure a burnished track for the rotor brush on the distributor head. This grease should be sparingly applied and the head wiped clean from dust and dirt.

Delco Voltage Regulator.—In the 1914 Delco systems a voltage regulator such as shown at C, Fig. 39 (Chapter II) is used. The

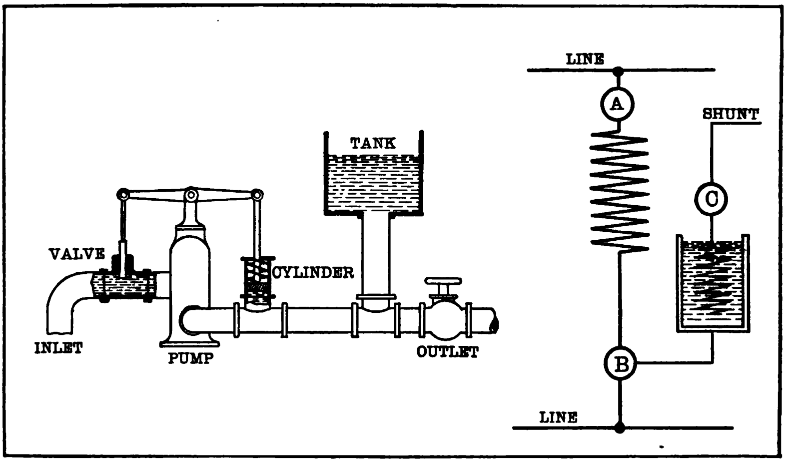


Fig. 175.—Simple Water Analogy to Outline Clearly the Operation of the 1913 and 1914 Delco Voltage Regulator.

function of this device is to prevent too much current flowing to the storage battery when the engine is running at high speed. As the voltage of the storage battery will vary with its condition of charge the intensity of the magnetic pull exerted by the solenoid A upon the plunger C varies and causes a contact attached to the plunger to move in and out of mercury which is contained in the bottom of the mercury tube B. When the battery is in a discharged condition the plunger C assumes a low position in the mercury tube, and when in this position the coil of resistance wire carried upon the lower portion is immersed in the mercury, and

as the plunger rises the coil is withdrawn. As the plunger is withdrawn from the mercury more resistance is thrown into the circuit and the greater resistance causes the amount of current flowing to the battery to be gradually reduced as the battery nears the state of complete charge until finally the plunger is almost completely withdrawn from the mercury, throwing the entire length of the resistance coil into the shunt field circuit, thus causing an electrical balance between the battery and the generator and eliminating any possibility of over-charging the battery. A description of the voltage regulator follows: A solenoid coil A surrounds the upper half of a mercury-containing tube B. A plunger C, comprising an iron tube with a coil of resistance wire R wrapped around the lower portion on top of mica insulation, is adapted to be drawn up into the solenoid as the battery current increases in strength. One end of this resistance coil is attached to the lower end of the tube, the other end being connected to a rod B in the center of the plunger. The lower portion of the mercury tube is divided into two concentric wells by an insulating member, the plunger tube being partly immersed in the outer well and the rod in the inner well. The space in the mercury tube above the mercury is filled with a special oil, which serves to lubricate the plunger as well as protect the mercury from oxidation. The device is connected to the shunt field of the generator so that the current must follow a path leading into the outer well of mercury through the resistance coil R to the rods carried at the center of the plunger, from thence into the center well of mercury and out of the regulator. The more the resistance coil R is pulled out of the mercury the more resistance is interposed in the field circuit and a smaller amount of the generator current is going to charge the storage battery.

The illustration at Fig. 175 makes the operation of the 1914 Delco voltage regulator easily understood and here again we use the water analogy. When the water tank is empty little resistance is offered to the flow of water into it. This means that but small pressure is necessary to overcome the resistance and to force the water into the tank. The regulating valve will remain wide open and allow a large quantity of water to be pumped. As the amount

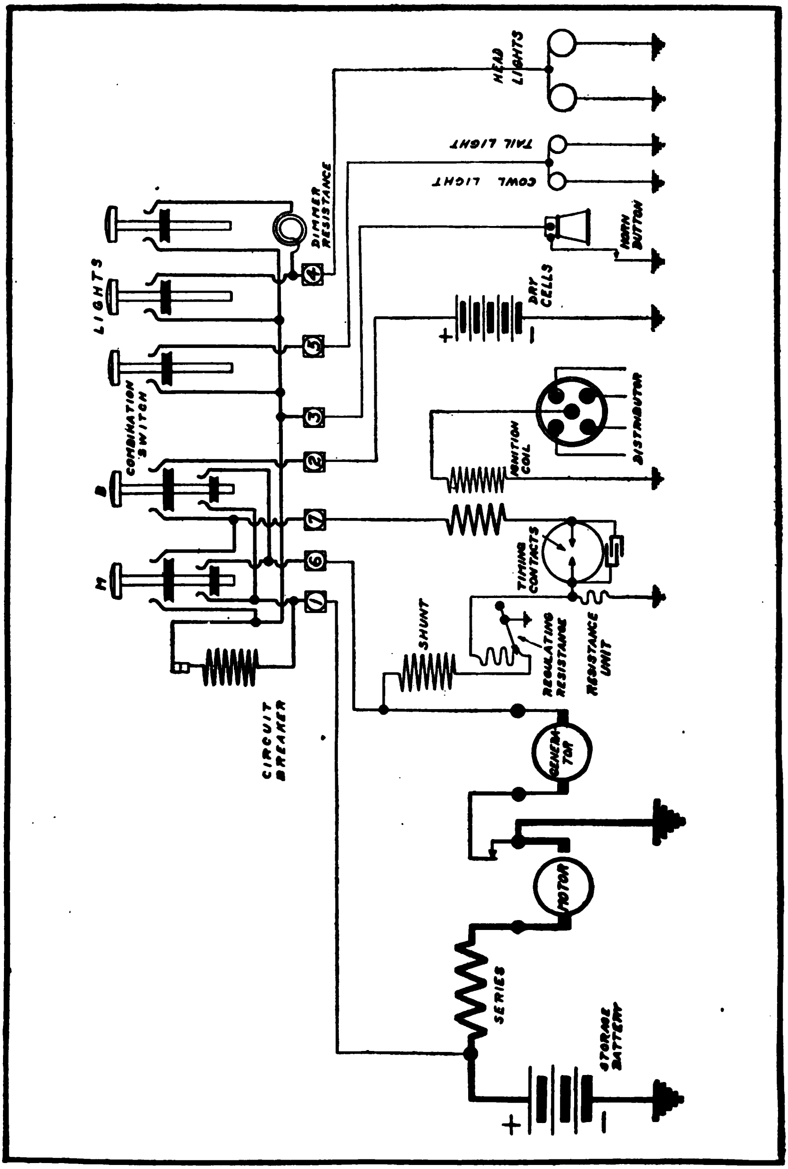


Fig. 176.—Wiring Diagram of Delco-Buick Starting, Lighting and Ignition System.

of water in the tank increases the pressure in the pipe line also becomes greater, and this increased pressure acting through the pressure cylinder flows into the valve and thereby decreases the flow of water. When the tank is about full of water the valve is so nearly closed that only a small amount of water is pumped. Considering the action from an electrical point of view, when the storage battery is discharged it offers but little resistance to the flow of the charging current. It does not require much voltage to produce a current flow in a circuit of low resistance so the current regulating plunger will remain low in its tube, this allowing a large quantity of current to be generated. As the storage battery becomes charged the pressure on the line increases and this acting through the voltage regulating coil lifts the plunger out of the mercury and reduces the flow of current. When the storage battery is fully charged the regulating plunger is nearly all out of the mercury and only a small amount of electricity is supplied to the battery.

It will be noticed that in the wiring diagram shown at Fig. 176 a protective circuit breaker is attached to the switchboard. The function of this device is to open the circuit between the source of current supply (generator and storage battery) and the current consuming units (lamps, horn and ignition apparatus) if one of the wires leading to a current consuming unit happens to become grounded. Under such a condition an excessive flow of current is possible on account of the lessened resistance of the circuit. Such a flow goes through the winding of the circuit breaking relay or protected circuit breaker, which produces a magnetic pull that opens the contact and cuts off the current supply. As soon as the contact is opened the magnetic pull ceases and the contact is closed again, re-establishing the magnetic pull and again opening the contact. The circuit breaker will continue to vibrate until the ground or short circuit is located and corrected whenever any one of the switches controlling the current consuming units is pushed in to establish a circuit. The function of this protective circuit breaker is the same as a fuse block and fuse except that it is not necessary to keep replacing fuses.

Method of Current Output Regulation.—The voltage regulator which has been previously described and which was used on the 1914 Delco Systems has been replaced by a system of "third brush excitation" in the 1916 systems. This has been very concisely described by the Delco engineers, and in order to make for accurate presentation of fact, the following descriptive matter is given in the same way as it appears in the Delco instruction books.

There is really only one point in regard to the generating of electrical energy which is difficult to understand, and the best of scientists are at as much of a loss on this point as the average electrician. This one point can be expressed in the one sentence which is as follows: "Whenever the strength of the magnetic field or the amount of magnetism within a coil is changed an electro-motive force is induced or generated." This is variously expressed, but can be resolved into the same sentence as originally given. One of the most common expressions is, "Whenever an electrical conductor cuts the magnetic field or cuts magnetic lines of force an electromotive force is induced." In order to measure this electro-motive force, it is necessary to make connection from each end of the conductor to a suitable meter, by doing this a coil would be formed. Therefore, this expression means nothing different from the original expression. On account of being more readily understood, this expression will be referred to in connection with the explanation of the action of the generator.

The amount of the voltage that is induced (or generated) in any conductor or coil varies directly with the rate of the cutting of the magnetic lines; *e.g.*, if we have a generator in which the magnetic field remains constant and the generator produces 7 volts at 400 R. P. M., the voltage at 800 R. P. M. would be 14 volts, and it is on account of the variable speed of generators for automobile purposes that they must be equipped with some means of regulation for holding the voltage very nearly constant. The regulation of this generator is by what is known as third brush excitation, the theory of which is as follows:

The motor generator consists essentially of an iron frame and a field coil with two windings for magnetizing this frame. The armature, which is the revolving element, has wound in slots on its iron

core a motor winding and a generator winding connected to corresponding commutators. Each commutator has a corresponding set of brushes which are for the purpose of collecting current from, or delivering current to the armature windings while the armature is revolving.

When cranking, current from the storage battery flows through the motor winding magnetizing the armature core. This acting upon the magnetism of the frame causes the turning effort. When generating the voltage is induced in the generator winding and when the circuit is completed to the storage battery this causes the charging current to flow into the battery. The brushes are located on the commutator in such a position that they collect the current while it is being generated in one direction. (The current flows one direction in a given coil while it is passing under one pole piece and in the other direction when passing under the opposite pole piece.) When the ignition button on the combination switch is first pulled out the current flows from the storage battery through the generator armature winding, also through the shunt field winding. This causes the motoring of the generator. After the engine is started and is running on its own power this current still has a tendency to flow in this direction, but is opposed by the voltage generated. At very low speeds a slight discharge is obtained. At approximately 7 miles per hour the generated voltage exceeds that of the battery and charging commences. As the speed increases above this point the charging rate increases as shown by the curve (Fig. 174). The regulation of this generator is affected by what is known as third brush excitation.

Since the magnetic field of the generator is produced by the current in the shunt field winding it is evident that should the shunt field current decrease as the speed of the engine increases the regulation would be affected. In order to fully understand this explanation it must be borne in mind that a current of electricity always has a magnetic effect whether this is desirable or not. Referring to Fig. 177, the theory of this regulation is as follows: The full voltage of the generator is obtained from the large brushes marked "C" and "D." When the magnetic field from the pole pieces N and S is not disturbed by any other influence each coil is

generating uniformly as it passes under the pole pieces. The voltage from one commutator bar to the next one is practically uniform around the commutator. Therefore, the voltage from brush C to brush E is about 5 volts when the total voltage from brush C to brush D is 6½ volts and 5 volts is applied to the shunt field winding. This 5 volts is sufficient to cause approximately 1¼ amperes to flow in the shunt field winding.

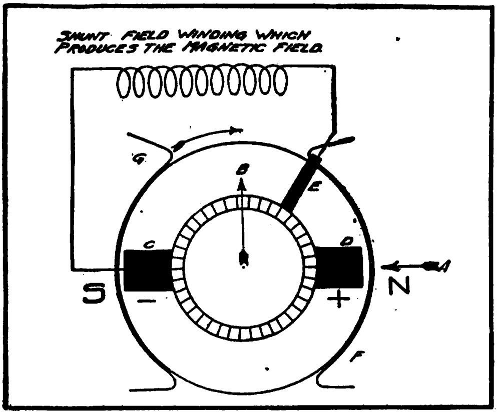


Fig. 177.—Diagram Showing Delco Third Brush Excitation Regulating Principles.

As the speed of the generator is increased the voltage increases, causing the current to be charged to the storage battery. This charging current flows through the armature winding, producing a magnetic effect in the direction of the arrow B. This magnetic effect acts upon the main magnetic field which is in the direction of the arrow A, with the result that the magnetic field is twisted out of its original position in very much the same manner as two streams of water coming together are each deflected from their original directions. This deflection causes the magnetic field to be strong at the pole tips, marked G and F, and weak at the opposite pole tips with the result that the coils generate a very low voltage while passing from the brush C to the brush E (the coils at this time are under the pole tips having a weak field) and generates a greater part of their voltage while passing from the brush E to D. The amount of this variation depends upon the speed that the generator is driven; with the result that the shunt field current decreases as the speed increases as shown in the curve.

By this form of regulation it is possible to get a high charging rate between the speeds of 12 and 25 miles per hour, and it is with

drivers whose average driving speed comes between these limits that more trouble is experienced in keeping the battery charged. At the higher speeds the charging current is decreased. The driver who drives his car at the higher speeds requires less current, as experience has taught that this type of driver makes fewer stops in proportion to the amount the car is driven than the slower driver. The output of these generators can be increased or decreased by

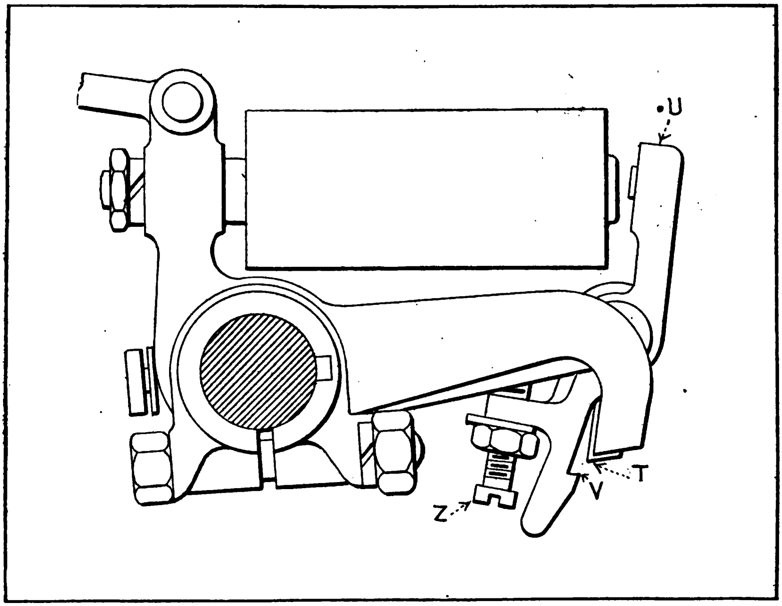


Fig. 178.—The Delco Magnetic Latch.

changing the position of the regulating brush. Each time the position of the brush is changed it is necessary to sandpaper the brush so that it fits the commutator. Otherwise the charging rate will be very low due to the poor contact of the brush. This should not be attempted by any one except competent mechanics, and this charging current should be carefully checked and in no case should the maximum current on this generator exceed 22 amperes. Also careful watch should be kept on any machine on which the charging

rate has been increased to see that the commutator is not being overloaded. Considerable variation in the output of different generators will be obtained from the curve shown, as the output of the generator is affected by temperature and battery conditions.

Numerous diagrams are presented to show the wiring scheme followed on representative Delco Systems also photographs showing practical application of the unit to the power plant.

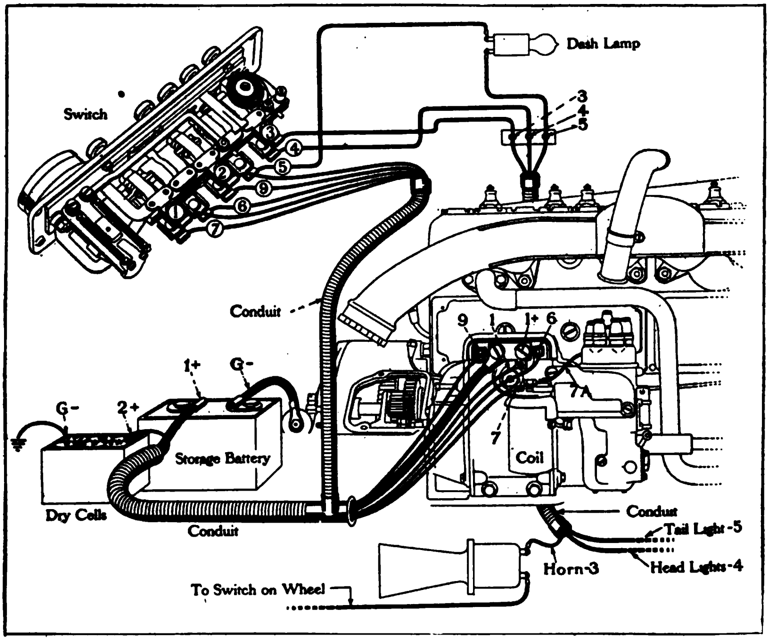


Fig. 179.—Non-Technical Wiring Diagram Showing Parts of the 1916 Delco-Hudson Ignition Starting and Lighting Systems.

Dyneto-Entz One Unit Electric System.—The advantages of the one unit system are said to be simplicity, light-weight, low cost and ease of installation, high cranking speed, higher operative efficiency, quiet starting and non-stalling in traffic. It is said by those who favor this system that it is good engineering to simplify any instrument or apparatus when it can be done without

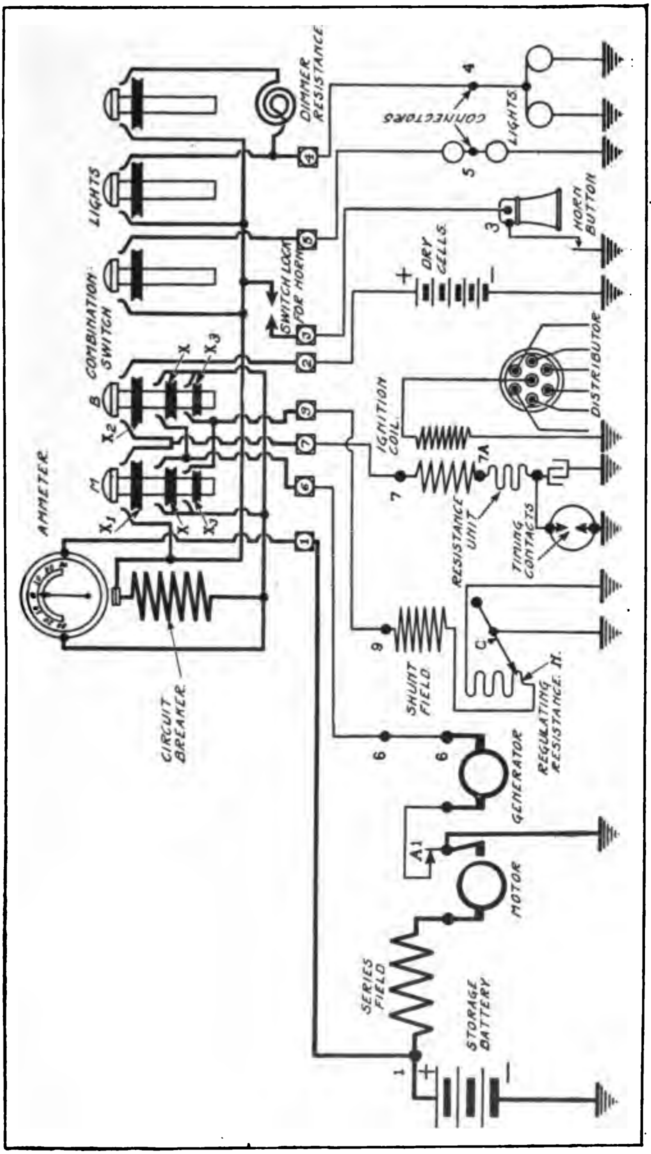


Fig. 180.—Technical Wiring Diagram Showing All Connections of the 1916 Delco-Hudson Ignition Starting and Lighting System.

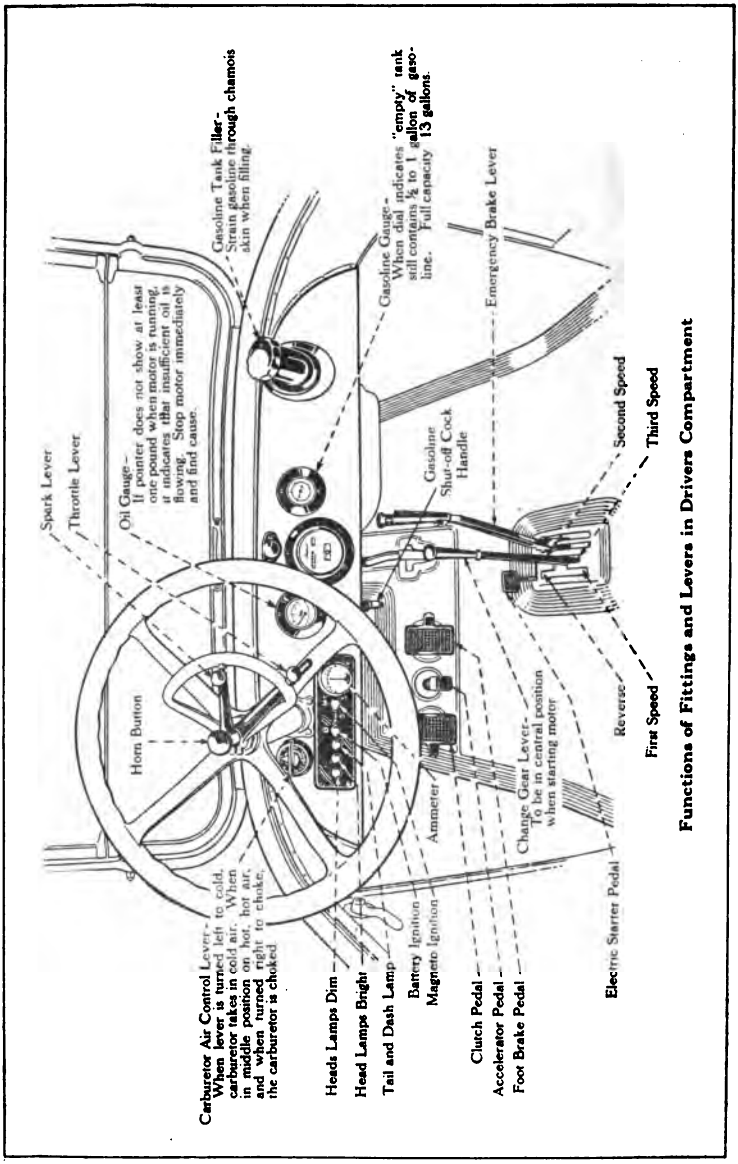


Fig. 181.—Driver's Compartment of 1916 Hudson Showing Location of the Various Controlling Elements.

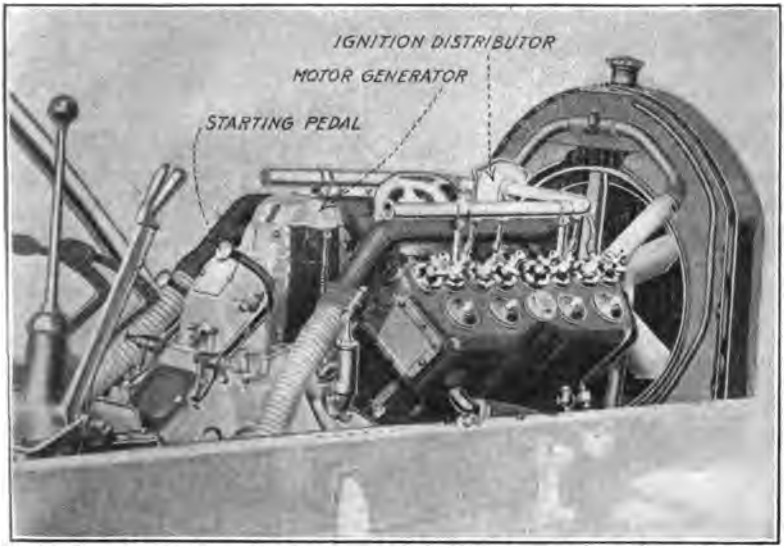


Fig. 182.—View of Cadillac Eight Cylinder Power Plant Showing Location of Delco Motor-Generator.

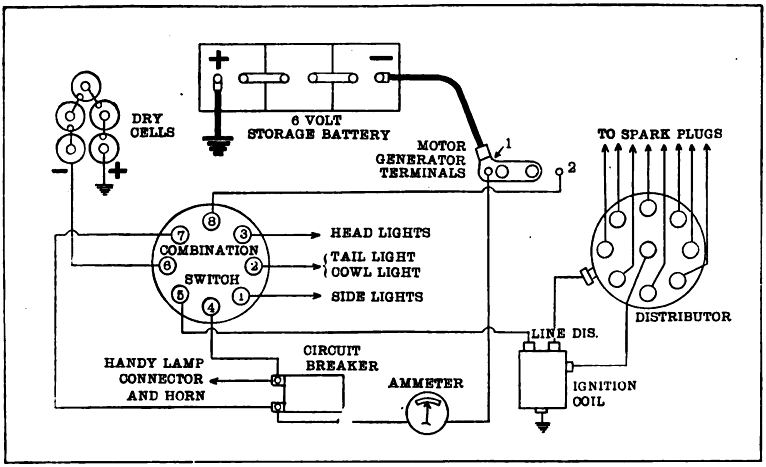


Fig. 183.—Wiring Diagram Showing Parts of the Delco Cadillac Eight Cylinder Type Starting, Lighting and Ignition System.

sacrificing efficiency or durability. The simplest designs are cheaper to manufacture and are not so apt to give trouble to the user. The single unit system is much simpler than the two-unit system and it is much easier to install because there is but one machine to set up, drive and wire up. The simplicity of the one-unit system means that there is but one set of bearings to oil, but one pair of brushes (if the device is the single commutator type), one simple and direct connection by silent chain and simple wiring.

The application of the one unit system to the chassis of a White car is shown in the plan view of the chassis at Fig. 184. The motor-generator is attached to a substantial bracket, back of the gear box and is connected to the engine by a driving shaft carrying a sprocket at its forward end just ahead of the shaft supporting bearing, this being in connection with a large sprocket attached to the engine flywheel, as shown at Fig. 185 by a silent chain. The storage battery is carried on the other side of the chassis frame just forward of the rear axle. To start this form of a one-unit system a switch is moved from the "off" position to the "start" position and it is left there until one desires to stop. In the White system the control switch is mounted on the steering column, as shown at Fig. 185. The Dyneto single unit system has no relays, automatic switches, overrunning clutches, sliding gears or current regulating devices. The usual manner of installation is to drive the motor generator with a silent chain so that the device turns at three times the motor speed. As the tendency is towards small bore, high speed motors, it is necessary that these be cranked over fast as they do not start easily at speeds of rotation below 100 r. p. m. The Dyneto-Entz starter will crank a four cylinder $2\frac{3}{4}$ inch bore x $4\frac{1}{2}$ inch stroke at a 172 r. p. m. on a six volt system drawing 40 amperes. A six cylinder, $3\frac{1}{4}$ inch bore x $5\frac{1}{2}$ inch stroke is cranked over at 140 r. p. m. on a 12 volt system drawing 35 amperes from the battery. It is said that less energy in watt hours is required of a storage battery at the high cranking speed because while the current output may be a little more, the time that the current is required to flow is much less in securing a positive start than it would be at the lower cranking speed.

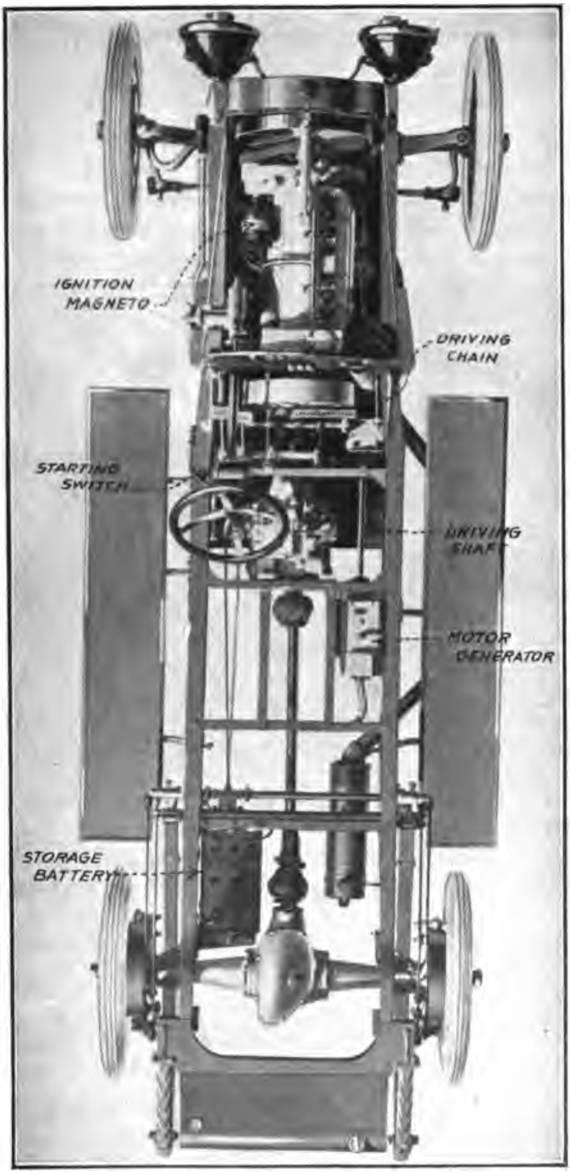


Fig. 184.—Plan View of White Touring Car Chassis Showing Location of Parts of Dyneto One Unit Starting and Lighting System.

One of the distinctive features of the Dyneto System is that it is non-stalling. This makes driving in traffic perfectly easy without changing gears every time the car is slowed down. This is because when the engine tends to run slower than a certain number of revolutions the device ceases to be a generator and becomes a motor, automatically drawing current from the storage battery instead of putting current into it. It is contended by those who

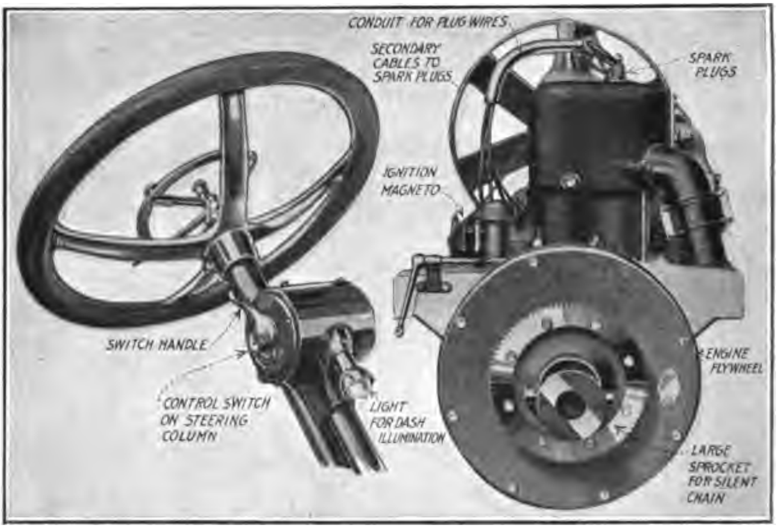


Fig. 185.—View at Left Shows Simple Control Switch of Dyneto-White Starting and Lighting System. Rear View of Motor at Right Shows Large Starting Sprocket Used on White Engine Flywheel.

do not favor the one unit system that the non-stalling feature makes a serious drain on the battery. It is said that no current is drawn from the battery at speeds above 8 m. p. h. and that very little is taken at any lower speed at which the car can be driven. When any current is drawn from the battery back through the motor-generator, the series field is strengthened and as this causes an increase of voltage it prevents to a large extent a back flow of current. The device changes from a motor to a generator at 5 miles per hour, and at a speed of 2½ m. p. h. a point that

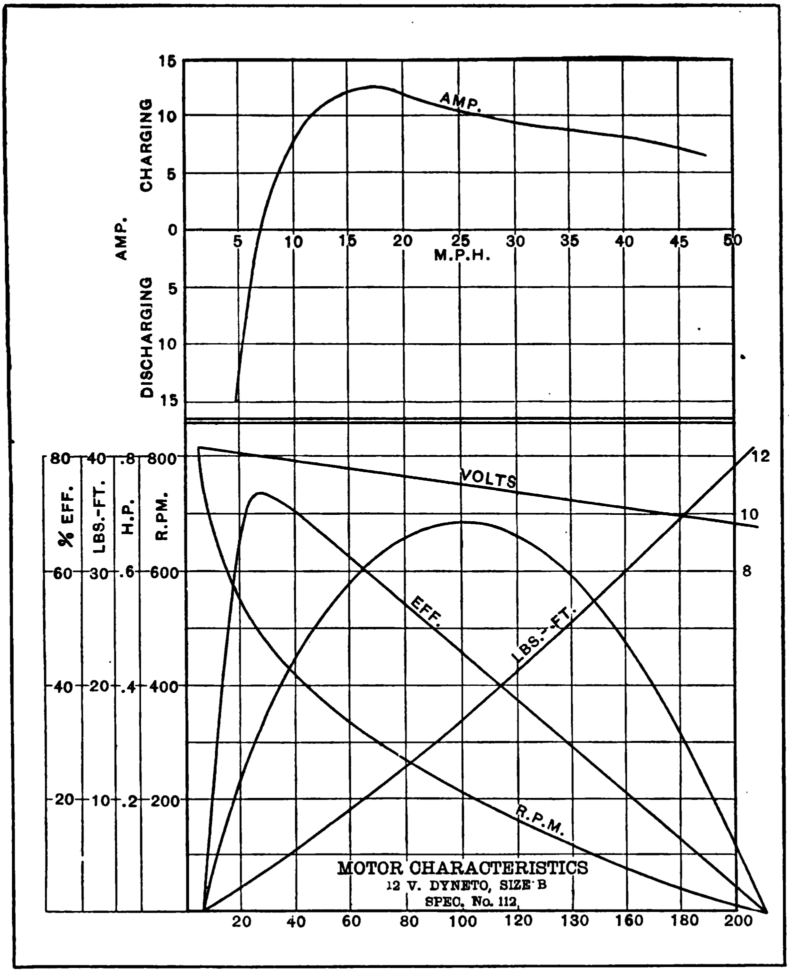


Fig. 186.—Motor Characteristic Curves of 12-Volt Dyneto Machine.

would never be reached except momentarily in traffic, a current of 10 amperes is drawn from the battery.

This back flow when it does occur is turned to advantage by preventing the gasoline engine stalling. It is necessary to take very fully into account the characteristics of the various motors

to which the machine is to be fitted and proportion the windings accordingly. It may be desirable on a car having a certain gear ratio to have the back flow occur at a somewhat higher speed than on another car. These factors are taken into consideration in designing the various systems. A number of curves are given at Fig. 186 showing the motor characteristics of a 12 volt Dyneto size B. It will be observed by consulting the upper diagram that in this case the device changes from a motor to a generator at a speed of 7½ m. p. h. If the speed is increased above this figure the machine becomes a generator and charges the storage battery. If the speed decreases the device becomes a motor and draws current from the storage battery. It will be observed that the Maximum current output of 12½ amperes is produced when the engine is turning over at a speed equivalent to 17½ m. p. h. From this point the current output falls so that at 47½ m. p. h. but six amperes are being generated. At 600 r. p. m. the machine delivers .6 h. p. and is working at 60 per cent. efficiency. Similarly, if used as a generator

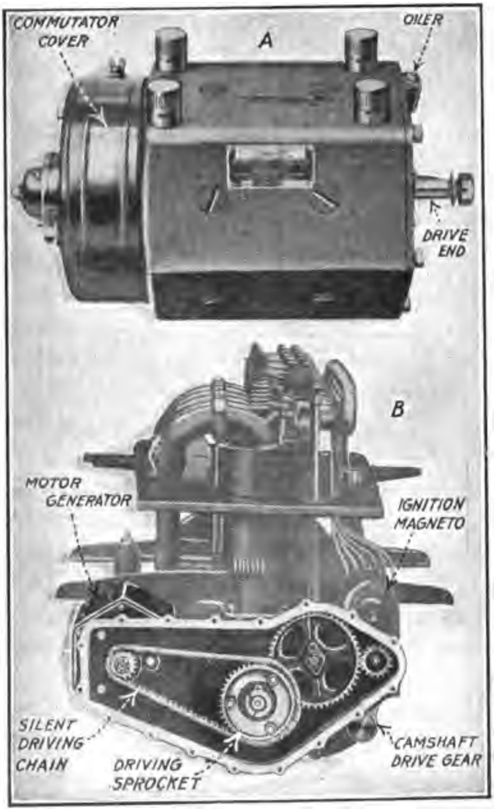


Fig. 187.—The Dyneto One Unit Motor-Generator at A and Latest Method of Installing It on Franklin Engines Shown at B.

it is consuming .6 h. p. at 600 r. p. m. At this speed it is capable of exerting the torque of 30 lbs. feet, which means a pull of 30 pounds at a distance of one foot from crankshaft center. Those technically informed will have no trouble in following the motor characteristic curves presented. The reader who is more interested in the practical application of the system than in the technical aspects will not be interested in curves of this nature.

Chalmers-Entz System.—This is used on the Chalmers Model 26 and is shown at Fig. 188. It comprises a motor-generator, battery, switch and regulating device. The feature of the installation is that it prevents the gasoline engine from stalling, even when the car is in gear. For all normal driving the dash switch is left in the position at the extreme right, or, in other words, the starting system is constantly connected with the motor. For constant driving at speeds in excess of 30 miles an hour the dash switch should be moved to the middle position in the slot. In this position the ignition of the motor is still operative, but the generative portion of the starting system is cut out so that the battery no longer is being charged. When there is a tendency for the engine to stop the electric motor automatically picks up and turns the engine over until proper firing occurs.

When the dash switch is thrown to the "on" position, current flows from the battery to the motor-generator, which as a motor revolves at about 100 r. p. m. As soon as the engine attains a speed of approximately 600 r. p. m., 6 to 8 miles per hour, car speed, the direction of the current, due to the way the switch is connected to fields and armature is reversed and the electrical machine then becomes a generator, which in turn charges the storage battery. In the illustration, showing the wiring of the Entz system, the voltages of the lamps are shown. In the case of the head lights, the small bulbs incorporated are also shown.

The Auto-Lite System.—The 1915 Overland cars use the Auto-Lite system, which is shown at Fig. 189, A. This is a six volt, three unit system, operating on the one wire principle. The ignition function is performed by an entirely distinct appliance from the starting and lighting systems, namely, a high tension magneto. Five wires run from this magneto, four of these running the spark

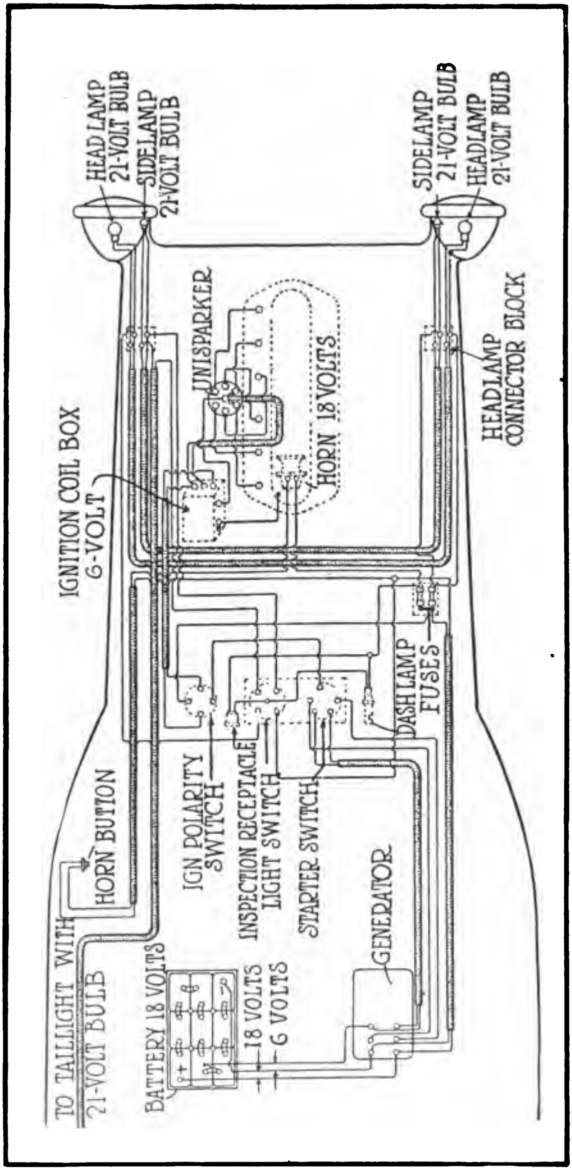


Fig. 188.—Wiring Diagram of Chalmers-Entz One Unit Starting and Lighting System.

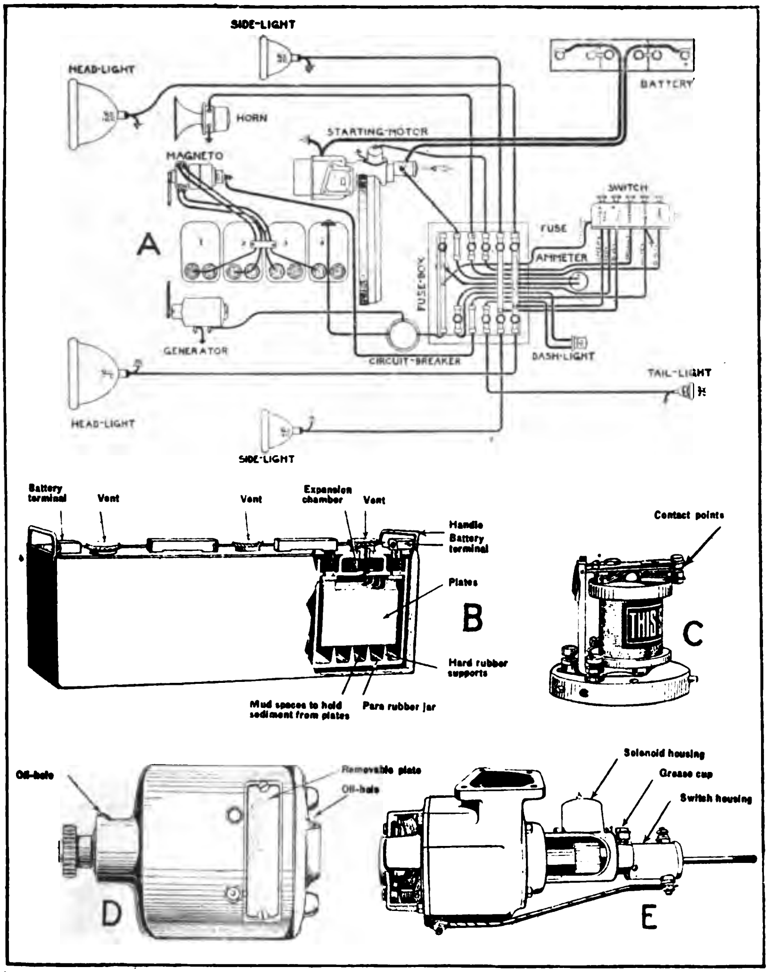


Fig. 189.—Diagram at A Shows Arrangement of Parts of 1915 Overland-Auto-Lite System and How They are Wired Together. B—Part Sectional View of Storage Battery. C—Automatic Circuit Breaker. D—Current Generator. E—Starting Motor.

plugs, one for interrupting the ignition through a fuse box to the controlling switch. The generator is driven from the motor crankshaft by a silent chain. The starting motor, which has the switch mounted integrally, turns the engine crankshaft through a gear cut on the flywheel rim. One of the wires of the generator is grounded, the remaining wire leading from that device runs through the circuit breaker and from that member through the fuse box and switch to the storage battery. Two wires run from the six volt

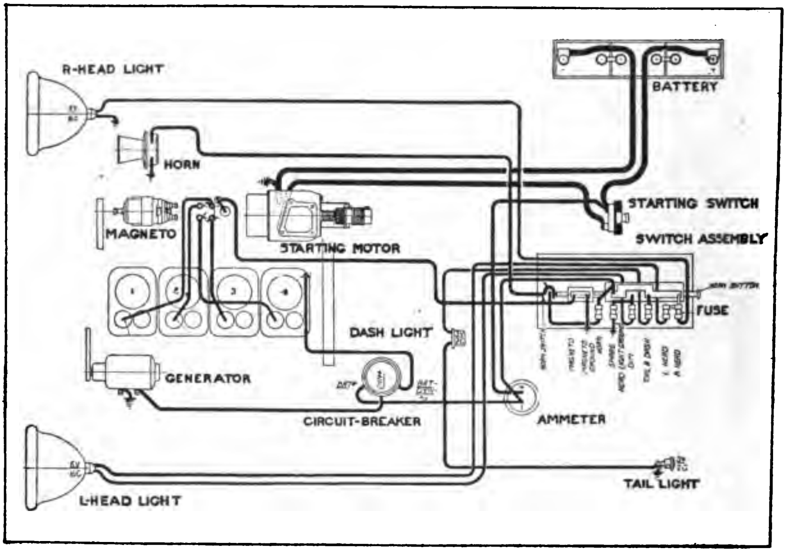


Fig. 190.—Wiring Diagram of 1916 Overland-Auto-Lite System.

battery, one of these terminating on a switch terminal of the starting motor while the other attaches to one of the motor terminals. The remaining motor terminal is grounded. The various appliances comprising this system are all clearly shown, and the wiring may be easily traced from the various units through the fuse box and switch by careful study of the diagram. In order to simplify wiring, the wires going to the switch are all colored differently. This insures that they will be replaced on the proper terminals if removed.

The storage battery used with this system is shown at Fig. 189, B. It is a special form, in which the three cells are placed end to end instead of side by side, making a long, narrow battery instead of the usual construction, which is approximately square. The construction of the circuit breaker is shown at C, the contact points, which are the only parts needing attention, being clearly outlined. The generator, which is a very simple device, is shown at B, the points requiring lubrication, and the removable plates for inspection of the brushes are clearly depicted. The starting motor is

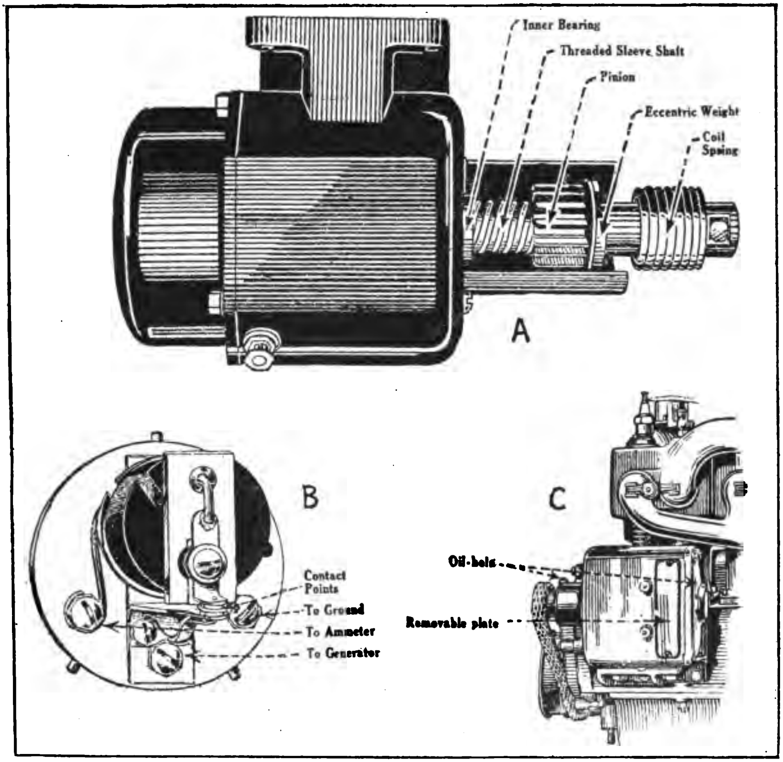


Fig. 191.—Starting Motor Used in 1916 Auto-Lite-Overland System with Automatic Pinion Shift at A. Automatic Cutout Shown at B. Method of Driving Generator with Silent Chain Outlined at C.

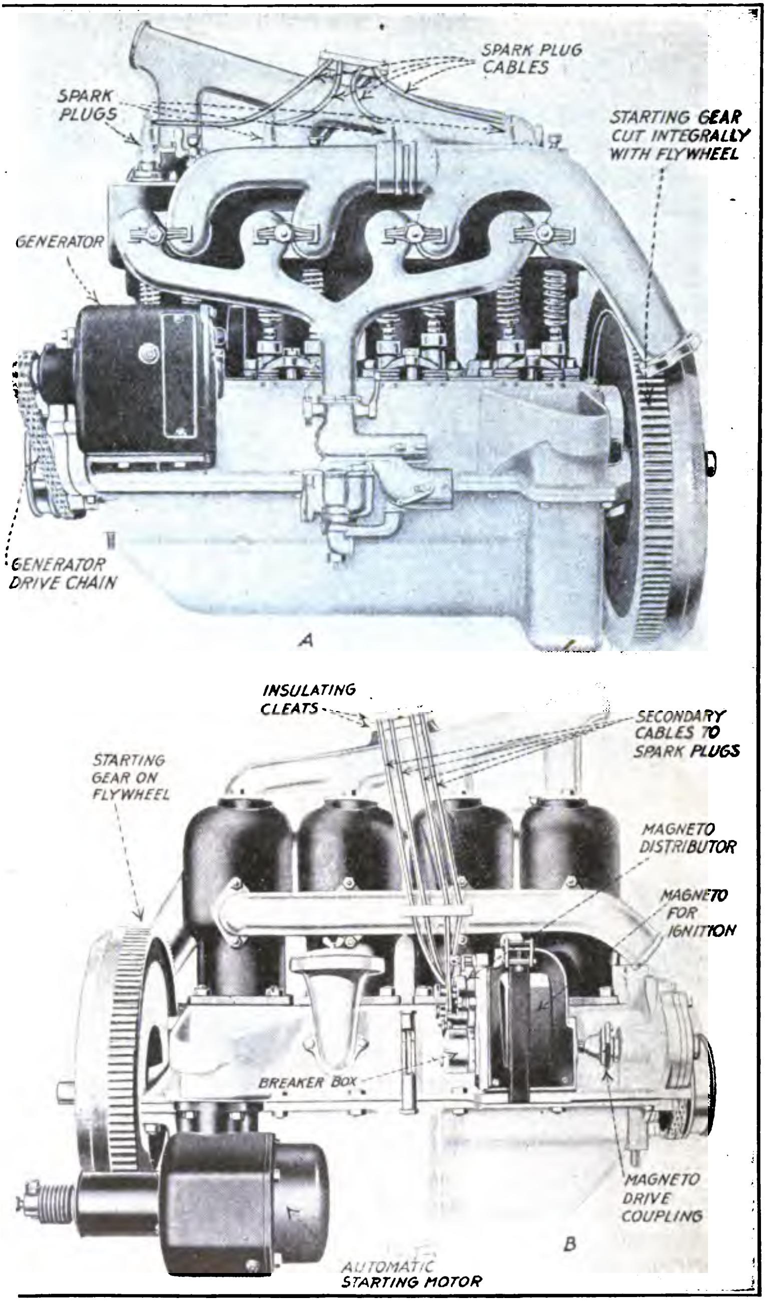


Fig. 192.—Views of Overland Four Cylinder Motor Showing the Application of the Current Generator at A and the Starting Motor and Ignition Magneto at B.

shown at E, the pinion which engages the gear on the flywheel is shown mounted on the armature shaft, and the cover, which normally covers the brush end of the motor, is removed in order to show the method of reaching the motor brushes when these members need attention.

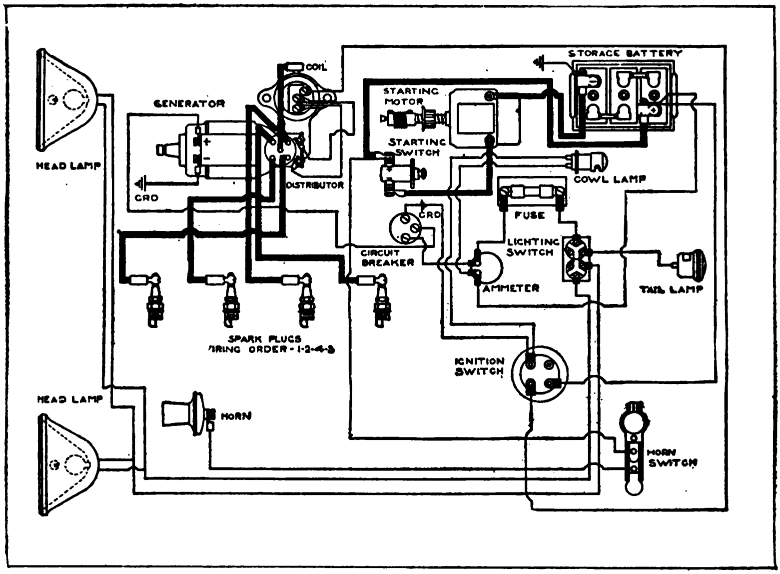


Fig. 193.—Wiring Diagram of Auto-Lite-Chevrolet Starting, Lighting and Ignition System.

The diagram Fig. 190 shows the 1916 Overland Auto-Lite system. This differs from the 1915 system principally in the use of an automatic pinion shift, and the units are changed slightly in detail as outlined at Fig. 191, in consequence. The application of the system to the four-cylinder power plant is shown at Fig. 192, while the method of installing the units on the six-cylinder Overland engine is depicted at Fig. 193.

Gray & Davis System.—The starting and lighting equipment used on the Model 79, 1914 Overland, is the Gray & Davis system, shown at Fig. 195, and comprises three principal units:

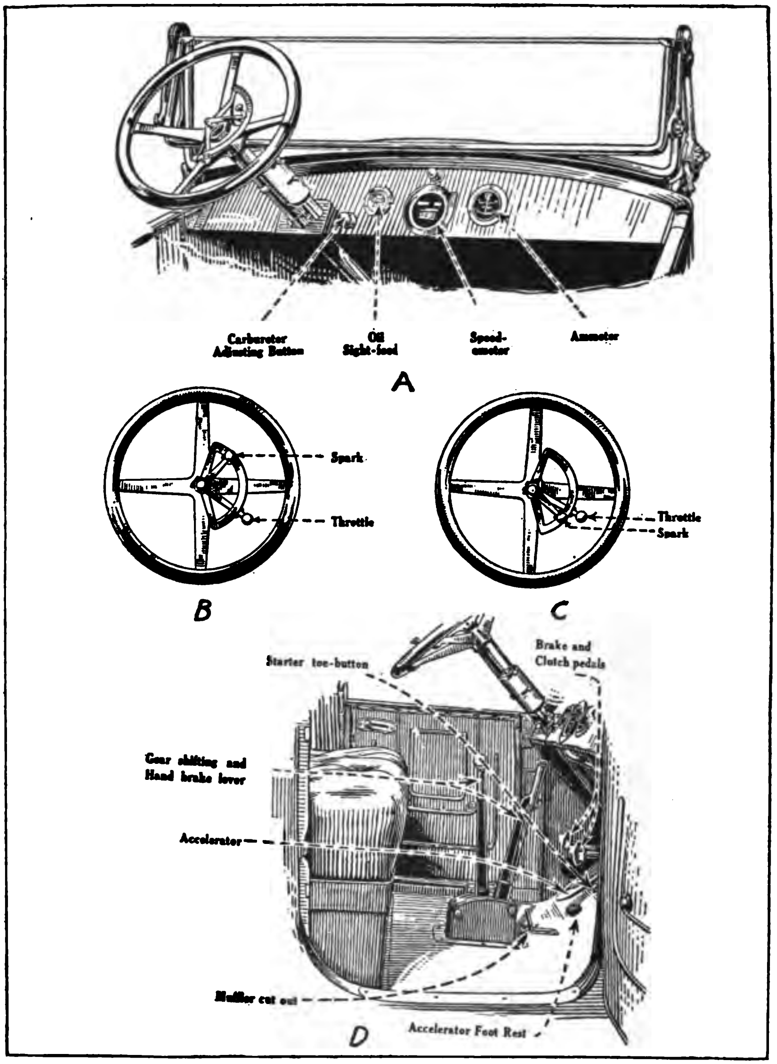


Fig. 194.—Views Showing Controlling Devices of 1916 Overland Car. Note Controlling Switch on Steering Column and Starting Switch Button Next to Accelerator.

a—The generator which produces the current and delivers it to the lamps and storage battery.

b—The storage battery which accumulates the current thus generated and delivers it to the lighting system or the starting motor, as occasion demands.

c—The starting motor, which receives current from the storage battery and revolves the engine whenever it is to be set in motion.

Besides these three principal units the system includes the following auxiliary apparatus:

d—An automatic cutout, whose function is to disconnect the generator from the storage battery when the engine is stopped or running below the speed at which the generator's voltage is high enough to charge the battery. The cutout is located on the engine side of the dash.

e—The starting switch, which is a pedal-button located in the floor board of the car convenient to the foot of the operator.

f—The ammeter, whose purpose is to show whether the system is working properly or not. When the dynamo is running and sending current to the storage battery the ammeter hand will point to the right of zero or at "charge." When the lights are burning or the starter motor is running, this hand will point to the left of zero or at "discharge," thus indicating the rate at which current is going out of the storage battery.

The speed of the generator is controlled by an automatic clutch that is so designed that, no matter how fast the engine runs, the generator will not be driven faster than a certain predetermined speed which corresponds to that at which the engine runs when driving the car at 12 miles per hour on high gear, but, of course, if the engine drops below this speed the generator will also. This is done by means of a centrifugal governor which regulates the slippage of the clutch so that the generator cannot be driven faster than the predetermined speed, the greater the speed of the engine the more the clutch slips.

The current load is automatically taken care of by a compound winding on the generator. The starting motor is a series wound machine, that is, the entire armature current passes through the field. The motor is provided with an over-running clutch, which

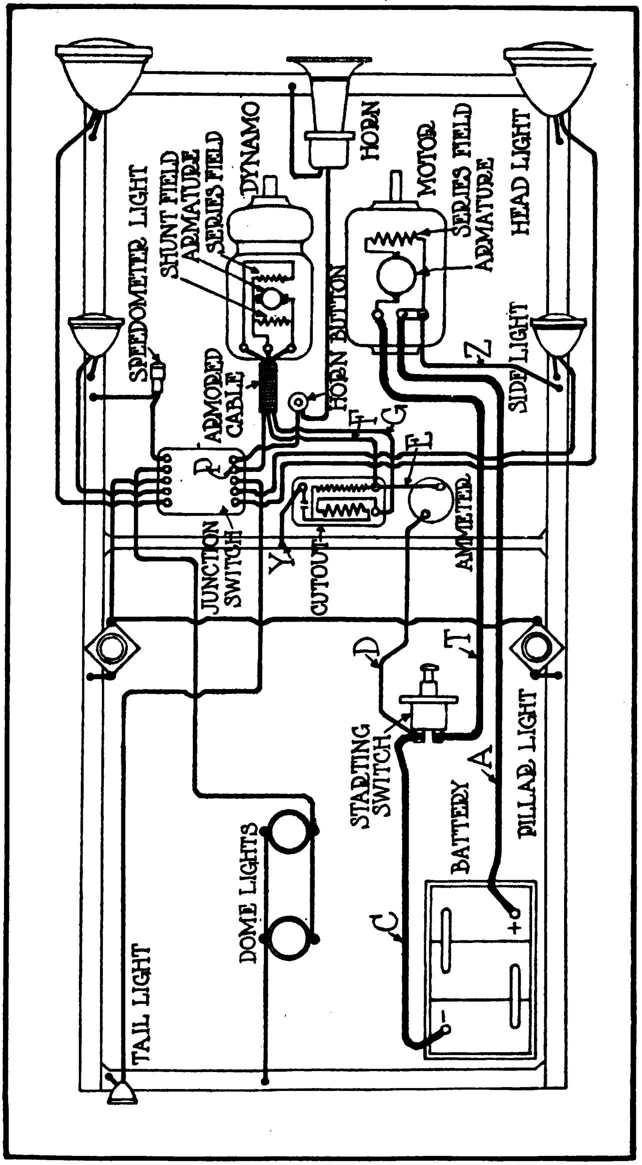


Fig. 195.—Wiring Diagram to Show Arrangement of Parts of 1914 Overland—Gray & Davis Starting and Lighting System.

allows it to drive the engine but automatically disengages when the engine starts so that the engine will not drive the motor. If such a device were not fitted the generator might be injured by the motor driving it at too high a speed.

As already explained, the function of the automatic cutout is to disconnect the generator from the battery when the engine is stopped or turning so slowly that its voltage is below that of the battery. If this cutout were not provided the storage battery would discharge back into the generator.

The cutout consists of an electro-magnet with two windings. One is a shunt winding of many turns of fine wire and the other a series winding of a few turns of heavy wire, both windings being over a soft iron core. The shunt winding is permanently connected across the positive and negative terminals of the generator, so that when the generator comes up to charging speed, this winding energizes the magnet core and the magnet core attracts a steel arm that closes the circuit between the generator and the battery.

So long as the cutout points are closed the current must pass through the series winding of the cutout. This current adds its magnetizing influence to that of the shunt winding and holds the points together. The cutout is designed so that it closes at a car-speed of 12 miles per hour and opens at 10.

If, now, the speed of the generator drops below charging speed, the current begins to flow through the cutout series winding in the reverse direction. This weakens the pull and allows the points to fly apart, through the agency of a spring.

Now that a general idea of the different parts of the Gray & Davis system has been obtained, the path of the current in the different wires will be explained. The illustration shows this system with a very complete equipment. Besides the usual head, side and tail lights, there are pillar lights, dome lights, a speedometer light and an electric horn connection. It will be noticed that the return circuits are through the frame, with the exception of the connections between the storage battery and the starting motor.

First we will trace out the flow of current when the starting switch is closed, this circuit being shown by the heavy black lines. Current flows from the plus terminal of the storage battery out

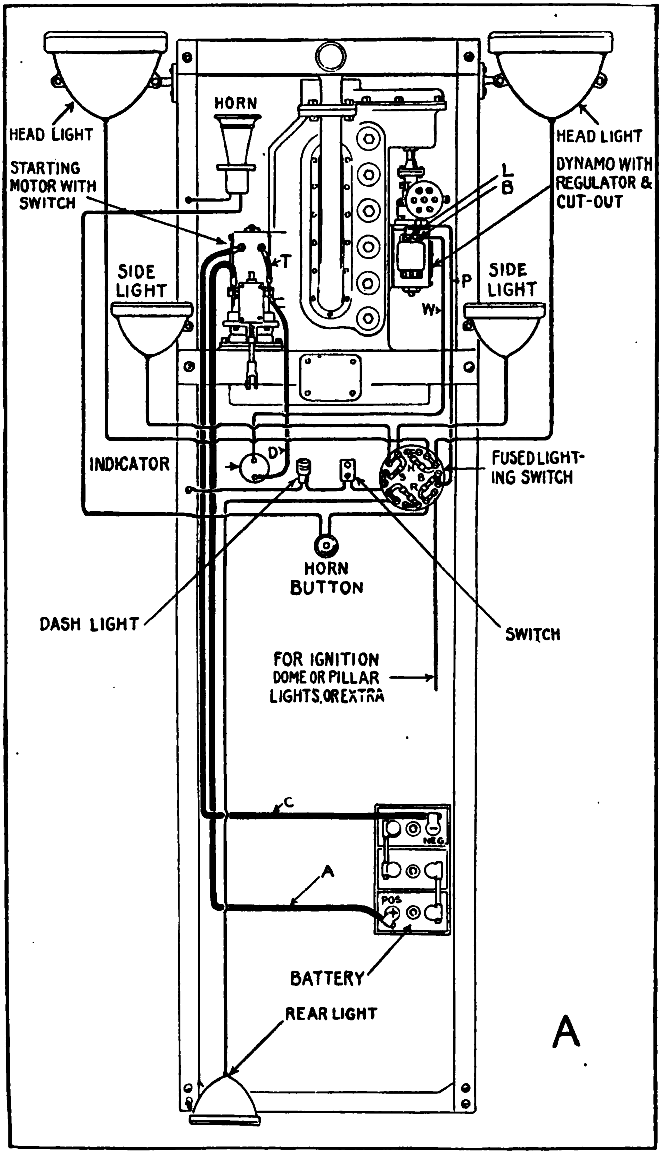


Fig. 196.—Non-Technical Wiring Diagram Showing Gray & Davis Two Unit, One Wire Lighting System

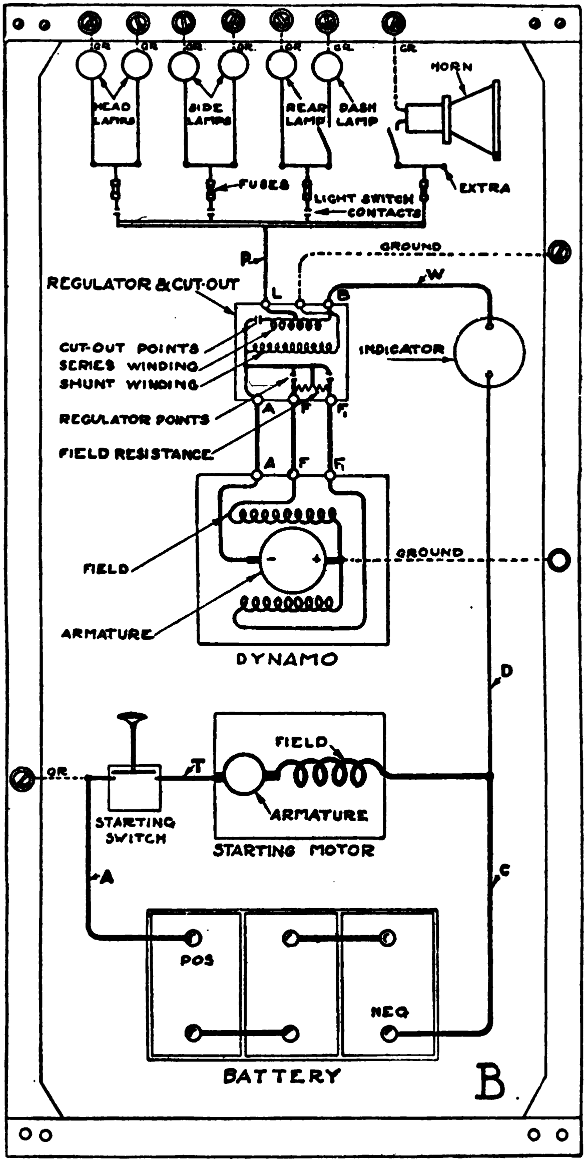


Fig. 197.—Technical Wiring Diagram Showing Circuits in Gray & Davis Two Unit Starting and One Wire Lighting System.

through wire A to the motor, where it passes through the series field and the armature and from thence through the wire T to the starting switch and from there through the wire C to the negative pole of the battery.

Below 9 or 10 miles an hour or when the motor is at rest the cutout is open and therefore current for the lights must be furnished by the battery, and its path is as follows: It runs out through wire A to one terminal of the starting motor, where it goes to the frame through the ground wire Z. From thence it runs to the lamps. From the lamps the current passes to the junction switch, where all the lamp terminals are connected to the terminal P, and from here the current flows through the series field of the generator and on out through wire F to a terminal on the cutout, and from thence to the ammeter over the short wire E. From the ammeter it goes via wire D to a binding post on the starting switch, from which it connects with the other pole of the battery by wire C. At or over 12 miles per hour the cutout contact points are closed as previously described. Current is then supplied to the storage battery if it needs charging and also to any of the lamps that are in circuit.

If the battery needs recharging it is of course below the voltage of the generator and therefore current will flow to it until its voltage becomes equal to that of the generator, when the flow will automatically stop because the electrical pressure at the two points is the same. The current passes from the positive terminal of the generator through wire G to the series coil of the cutout and from thence through wire Y to the frame. It flows through the frame up through wire Z to one terminal on the motor and from thence through wire A to the plus pole of the battery. The return circuit is through wires C and D to the ammeter and from thence through wires E and F back to the generator. The flow of current from the generator to the lamps is as follows: Through wire G and the series coil of the cutout and wire Y to the frame. This part of the circuit is identical with that for charging the storage battery. Then the current goes through the frame and up through the ground wires to the lamps, from whence it passes to the terminals on the junction switch and on through wire P to the generator. It will

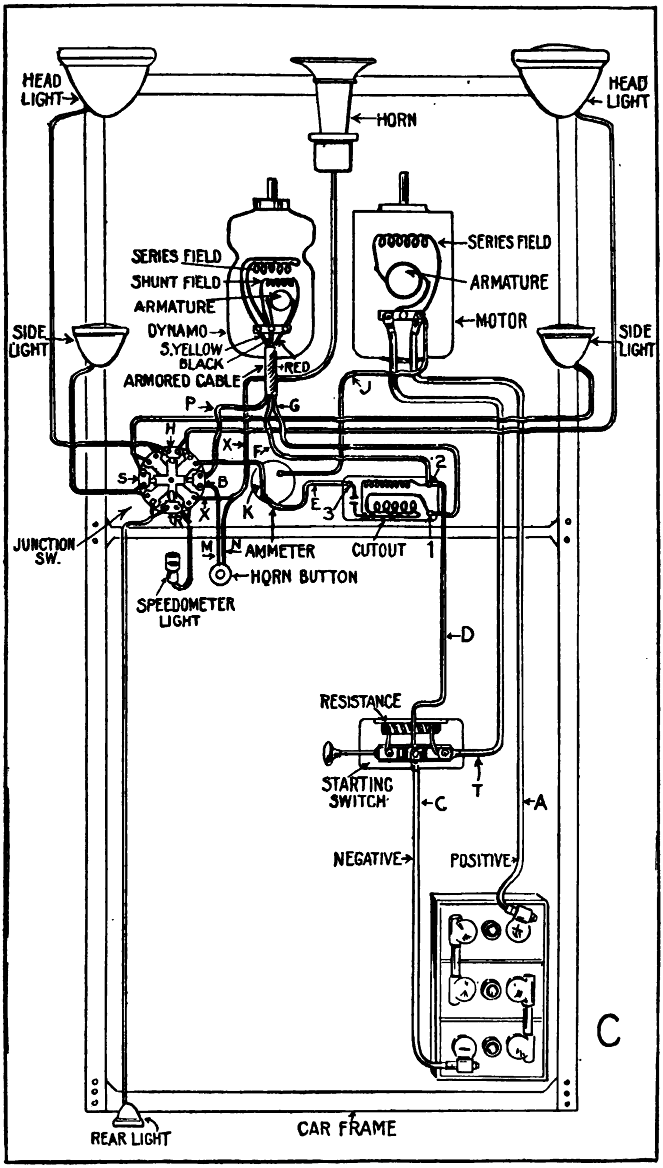


Fig. 198.—Non-Technical Wiring Diagram Showing Arrangement of Parts of Gray & Davis Two Unit, Two Wire Starting and Lighting System, Utilizing Centrifugally Governed Generator.

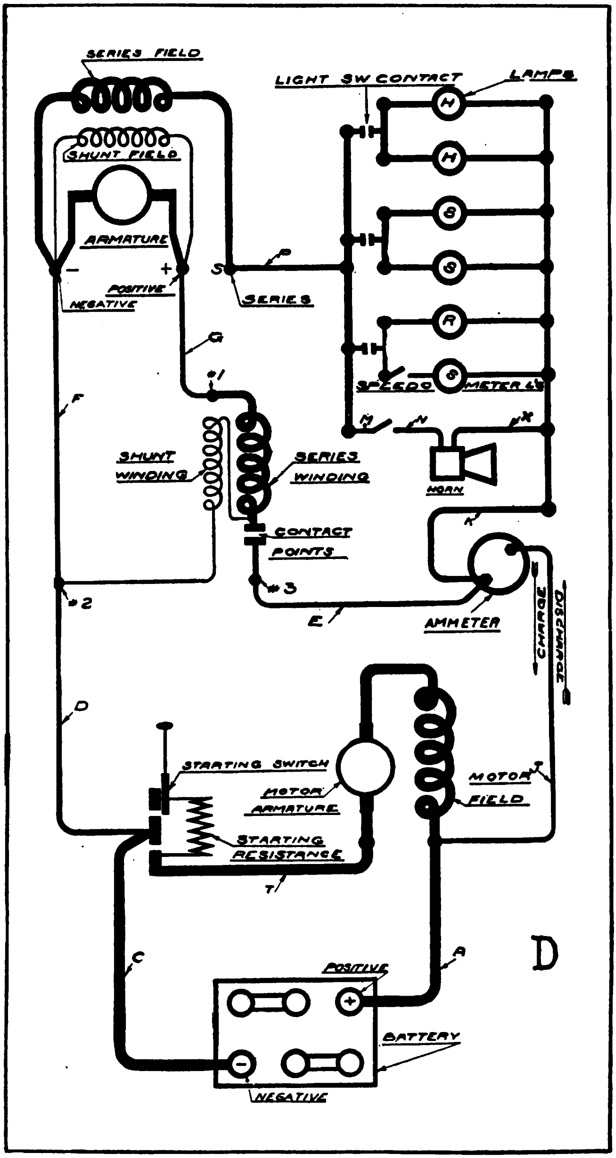


Fig. 199.—Technical Wiring Diagram Showing Circuits of Gray & Davis Two Unit, Two Wire Starting and Lighting System.

be noted that the generator and battery circuits to the lamps are independent, so that should anything happen to the battery, the lights could be operated by the generator alone.

Diagrams of Gray & Davis 1915 systems will be found on diagrams, Figs. 196 to 199 inclusive, in both non-technical and technical form. A number of parts comprising the 1915 Gray & Davis starting system is shown at Figs 200 and 201. The construction of the type Y motor used in connection with engines of the open flywheel type is clearly shown in the part sectional view at the top of the illustration. As the Gray & Davis systems may be had in either the one wire or two wire type, two forms of switch are provided. One of these, which is shown at B, Fig. 200, is used in a two wire system and has both terminals insulated. This must be wired up as shown at E. The heavy leads from the storage battery are connected as indicated. One of the storage battery terminals is connected to the terminal on the starting motor, while the other starting motor terminal wire goes to one of the insulated switch terminals. The other insulated switch terminal is connected directly to the remaining storage battery terminal. When used in connection with the one wire system the starting switch has one terminal grounded, as shown at C.

The approved arrangement of the starting switch is as depicted at the top of the illustration, in which the contact is not established until the sliding pinion has been meshed with the gear of the flywheel. The construction of the overrunning clutch used with the Gray & Davis system is shown at D. This functions the same as the overrunning clutch previously described, the drive being secured between the member 4, which is keyed to the intermediate shaft, and the reduction gear 2, which is turned by the motor pinion 1 through the medium of the clutch rolls 3. Light coil springs are employed to push plungers, designed to make more positive the engagement of the rolls of the overrunning clutch.

The fuse block, which is an important adjunct of the one wire system, is combined at the rear of the lighting switch, as shown at A, Fig. 201. The function of the fuse is to burn out should an overload occur in any circuit due to damaged insulation. The fuses are readily renewable, these being shown at D. The fuse con-

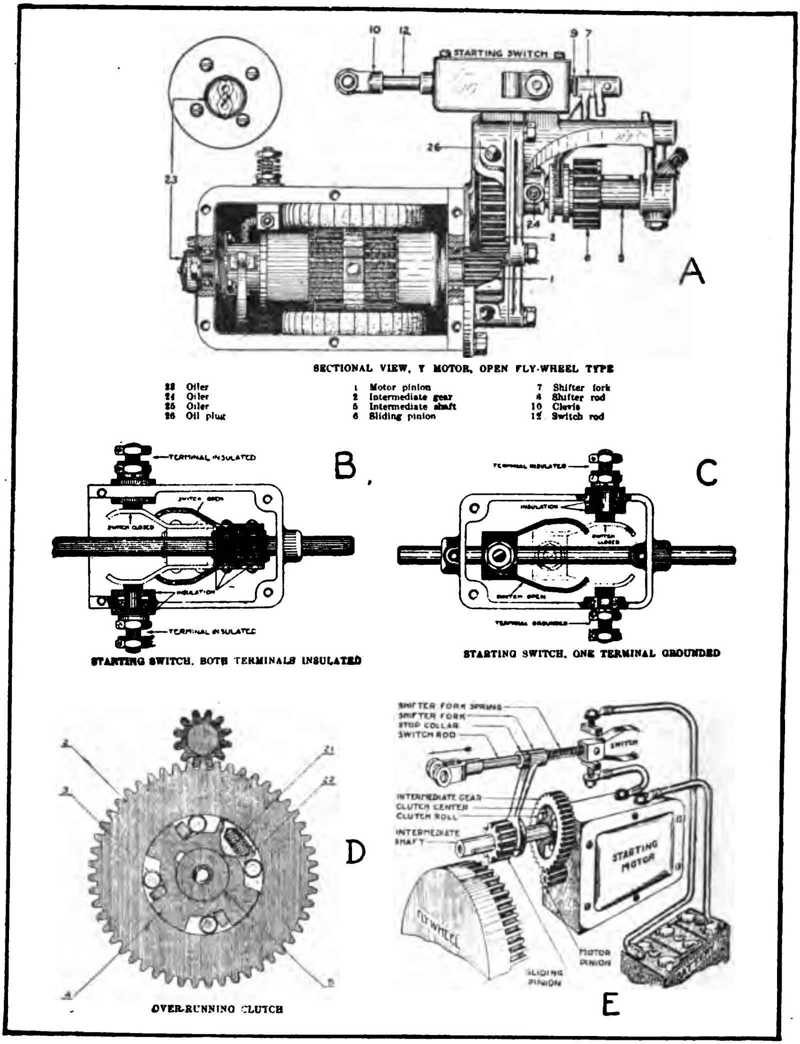


Fig. 200.—Group of Parts of Gray & Davis 1915 Starting and Lighting System.

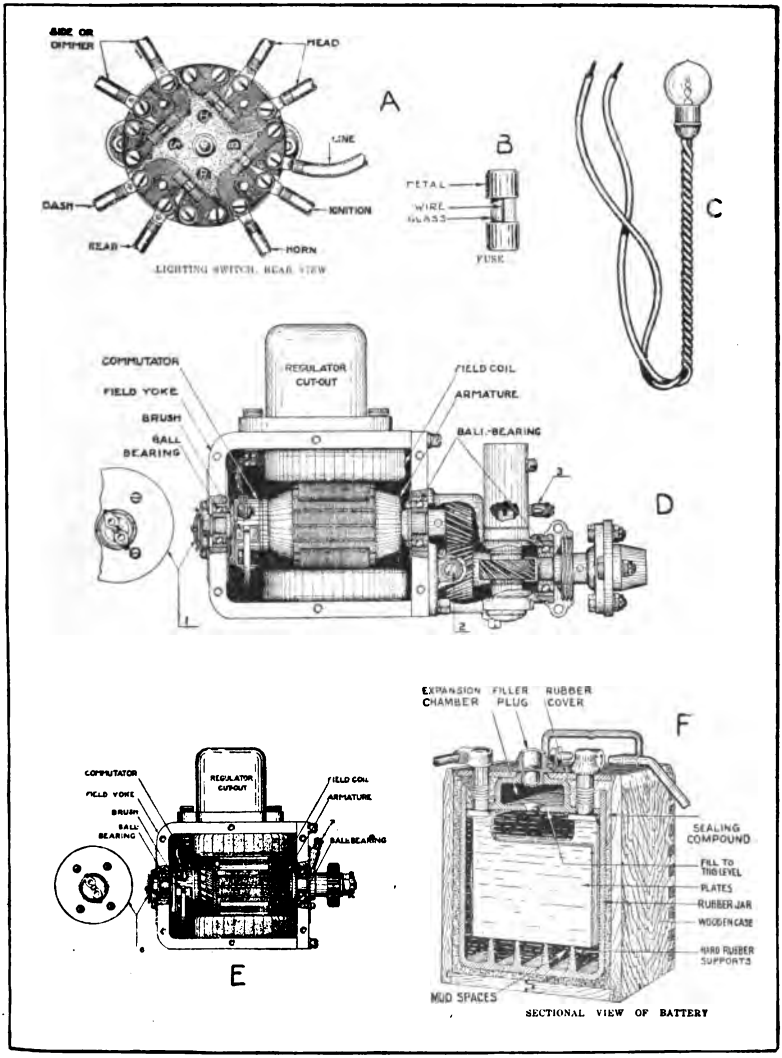


Fig. 201.—Group Showing Miscellaneous Components of 1915 Gray & Davis Starting and Lighting System.

sists of a glass tube, which contains a piece of fusible alloy wire that joins two metal caps, these caps being used to establish contact with the clips on the sides of the connectors at the back of the switch. The fuses should be handled carefully, and in removing same for examination it is well to do this with a sharp piece of

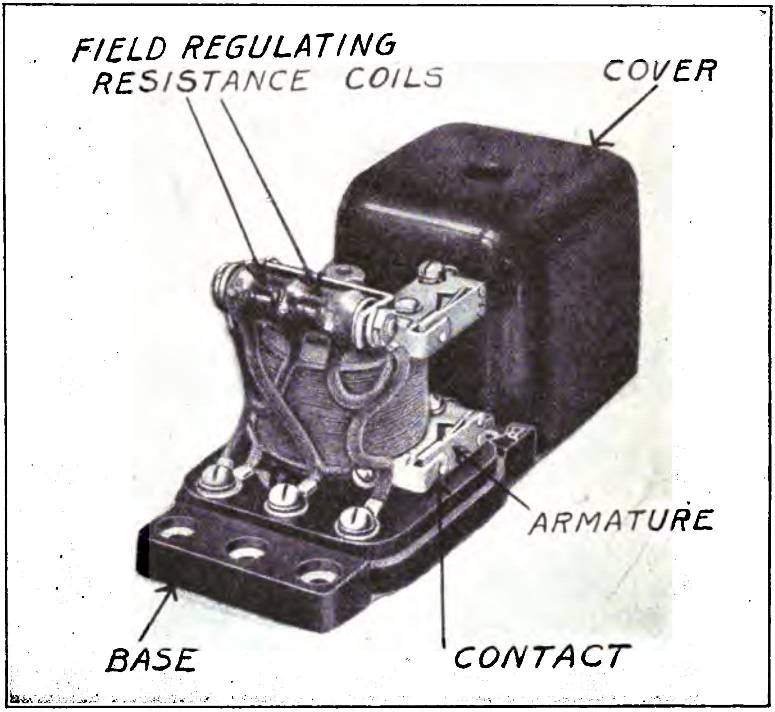


Fig. 202.—The Gray & Davis Automatic Cutout and Current Regulating Relay on 1915 Systems.

wood, which is used as a pry back of the fuse instead of attempting to remove them with pliers or a screwdriver, which may break the glass or otherwise damage the fuse. An important adjunct to assist in locating trouble is a six volt lamp, such as shown at C. This is of material assistance in tracing circuits.

The latest form of Gray & Davis dynamo, which dispenses with

the centrifugal governor used on the other types illustrated, is shown at D, supplied for direct drive by an extension of the timing gear shaft and for chain drive at E. The dynamo shown at D is provided with gearing to drive a timer distributor for ignition purposes. The current supply is governed by the regulator cut-out (Fig. 202), which performs two duties in the new systems. One of

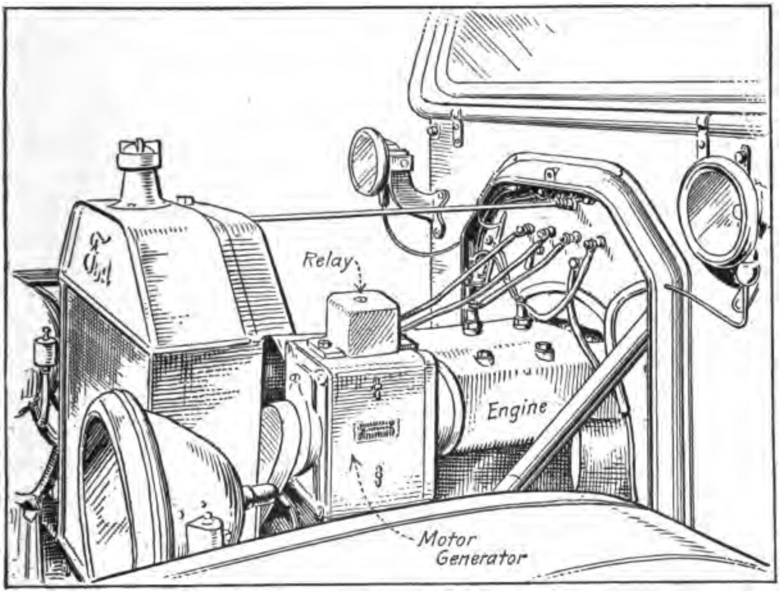


Fig. 203.—View Showing Application of Special Gray & Davis One Unit Ford System.

these is to regulate the dynamo to secure uniform current output, while in the other instance it connects the dynamo into the system only when sufficient current is generated to charge the battery. Current regulation is provided by short circuiting or shunting field resistances or to insert the field resistances into the field circuit. The object of the field resistance is to retard the flow of current in those windings. When the dynamo is at rest the cutout points are opened and the regulator points closed. As the dynamo first speeds up the regulator points remain closed and the field resistance is short

circuited. This permits the dynamo to build up its full field strength. When the proper voltage is reached the cutout points close, permitting current to flow through the series winding to the system. As the dynamo speed increases beyond that necessary for full output, the pull of the shunt winding attracts the regulator armature. This reduces the pressure at the regulator points and inserts a resistance into the field circuit, this preventing further increase of output. The frequency with which the resistance is put into the circuit is in proportion with the amount of speed variation. The form of battery used with the Gray & Davis system is shown in part section at F, Fig. 201. It does not differ materially in structure from types previously described.

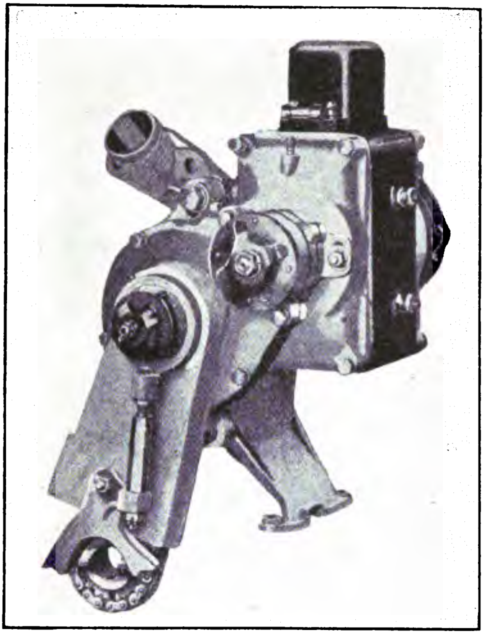


Fig. 204.—The Gray & Davis One Unit Starting and Lighting System Adapted for Ford Automobiles.

One Unit Ford Systems.—When one considers the large number of Ford cars that are in daily use, and that these are not provided with an electric starting system by the maker, it will be apparent that a fertile field is opened up among Ford users for the sale of starting motors. Practically all Ford systems are of the one unit type, because these constructions are especially well adapted for use at points where simplicity is essential. The Gray & Davis one unit system is shown installed at Fig. 203, and ready for installation on the motor at Fig. 204. The armature is driven from the engine

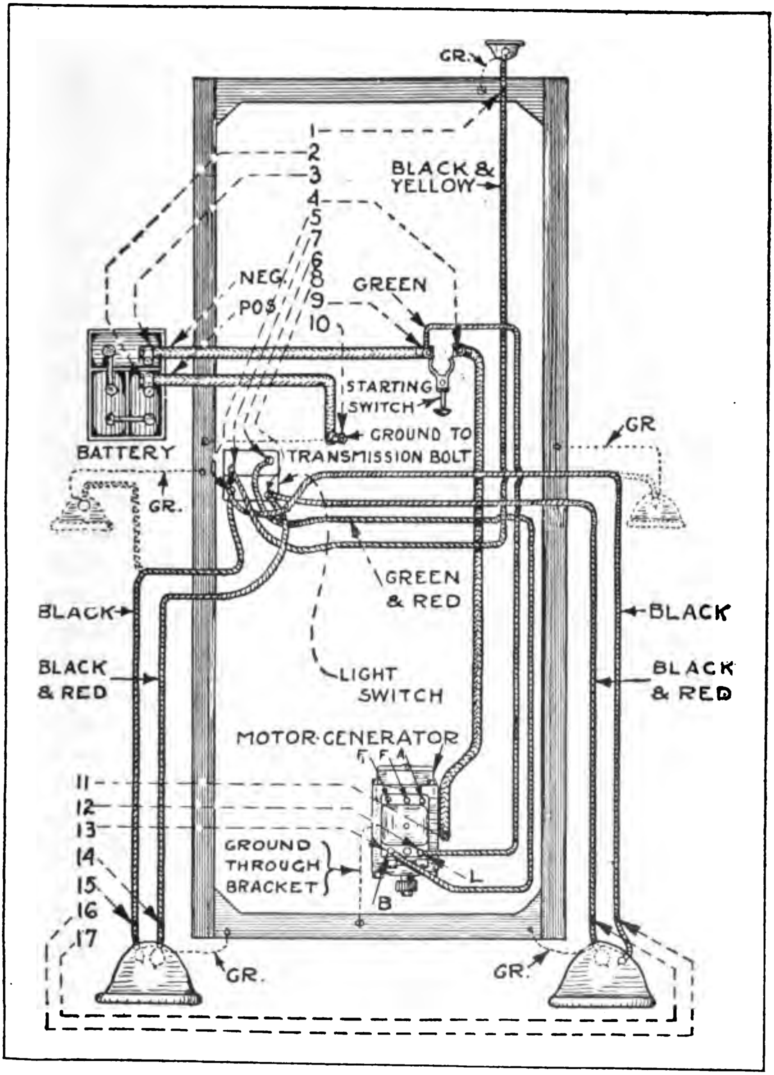


Fig. 205.—Wiring Diagram Showing Method of Connecting Parts of Gray & Davis One Unit Ford System.

crankshaft by two chains which provide a double reduction. The machine is so constructed that it is adapted to fit a special bracket that makes it possible to install the device on any Ford motor without structural changes. The wiring diagram shown at Fig. 205 is extremely simple. The six volt storage battery has its positive terminal grounded while the negative terminal is connected to the motor generator by a heavy wire which must first pass through the starting switch. The circuit is completed by a ground connection through the supporting bracket when the starting switch is depressed. There are two terminals on the cutout relay on the top of the motor generator; one of these is marked L, the other B. Terminal L leads to the negative of the storage battery, being attached to this lead on the battery side of the starting switch. Terminal B leads to the lighting switch. The remaining wires are easily followed, these leading to the various lamps, all of which operate on the one wire system.

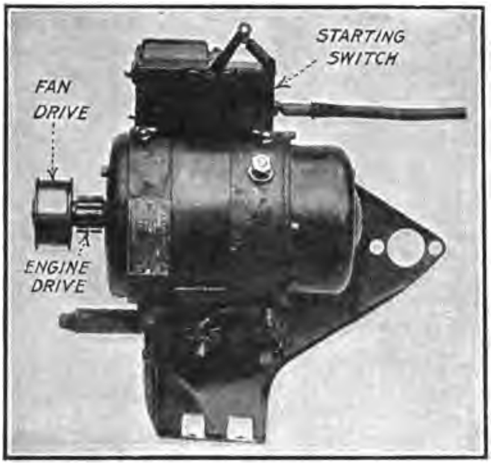


Fig. 206.—The Genemotor One Unit System for Ford Cars.

The Genemotor which is shown at Fig. 206 is made by the General Electric Company, and is a single unit operating on twelve volts. It is permanently connected to the engine shaft by a single Morse silent chain, the ratio of reduction being two to one, which provides sufficient torque for starting the motor while at the same time the maximum armature speed is limited to a safe value. The device becomes a generator at a car speed of 12 m. p. h. on the direct drive. The motor generator is about 11 inches long, 7 inches in diameter, and weighs 52 pounds. It

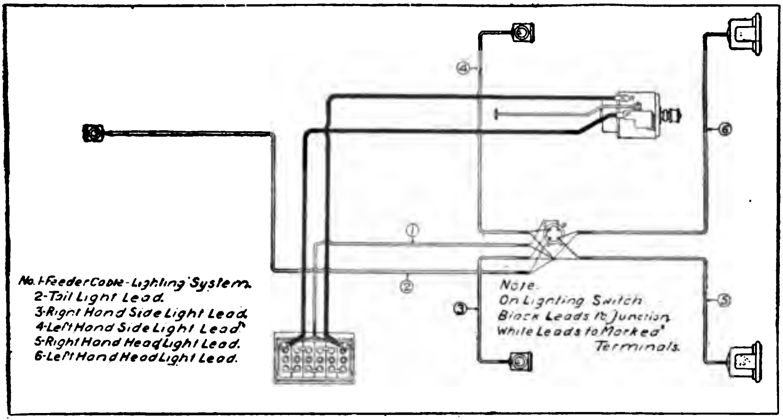


Fig. 207.—Wiring Diagram of Genemotor-Ford Starting and Lighting System.

gives a starting torque of 86 foot pounds at the engine crankshaft, or 43 foot pounds at the armature operating with the 42-ampere hour battery supplied with the system. It is mounted on a pressed steel bracket designed for attachment at the left side of the engine. The bracket rests on the cylinder base bolts and is held rigidly in place by clamping it under the two water

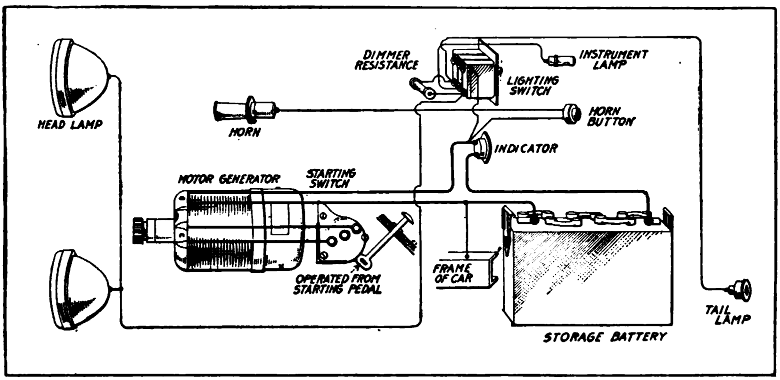


Fig. 208.—Wiring Diagram Showing Parts of Dodge-North East One Unit Starting and Lighting System.

connections, and adjustment is provided to keep the chain the proper tension by two set screws in the bracket cradle. A flexible drive is provided between the Genemotor armature and chain to absorb all shocks on the chain. The starting switch and cutout are mounted on top of the Genemotor, making an integral con-

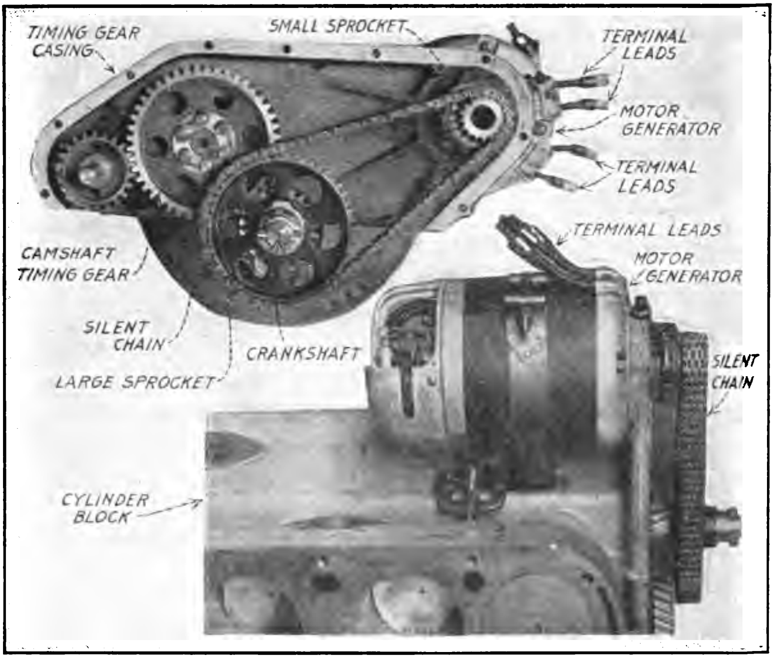


Fig. 209.—Method of Driving Dodge-North East Motor Generator by Silent Chain Connection with Engine Crankshaft.

struction. When starting the machine acts as a compound wound series motor. As a generator the shunt field predominates. Current regulation is secured by means of a third brush excitation principle. The wiring diagram is very simple and can be readily followed by referring to Fig. 207.

The Northeast Lighting and Starting System.—The Northeast System comprises a motor generator, starting switch, lock

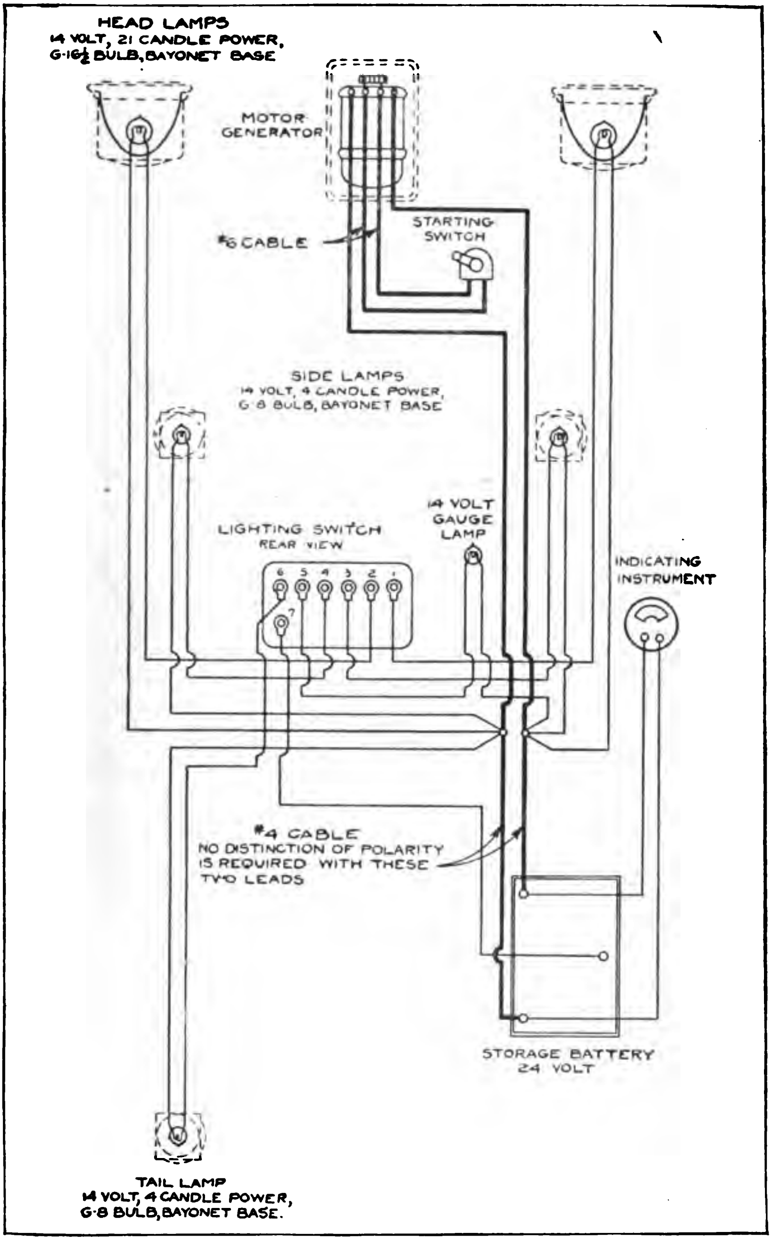


Fig. 210.—Wiring Diagram Showing Circuits of North East One Unit 24-Volt Starting and 12-Volt Lighting System.

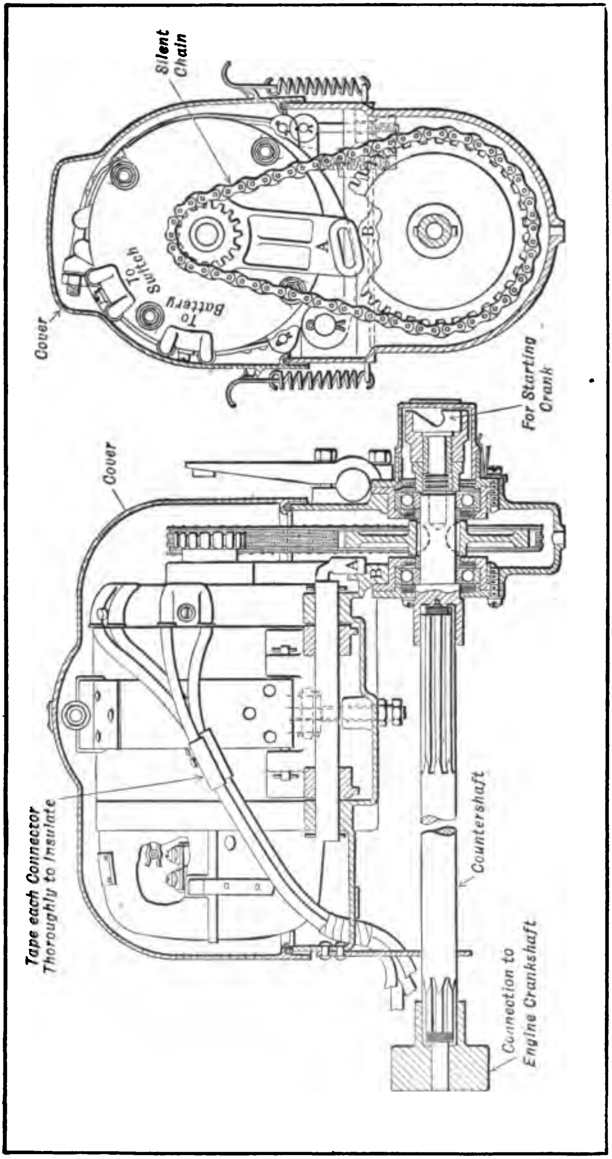


Fig. 211.—Construction of the North East Universal Starting and Lighting Unit.

switch, and a battery, together with suitable gearing by which it may be coupled to the engine, and in common with other one unit systems it is very simple in operation. Parts comprising the Northeast System used on the Dodge car are clearly shown in the diagram, Fig. 208, which also shows all the connecting wires that form the circuits between the different elements. The method of

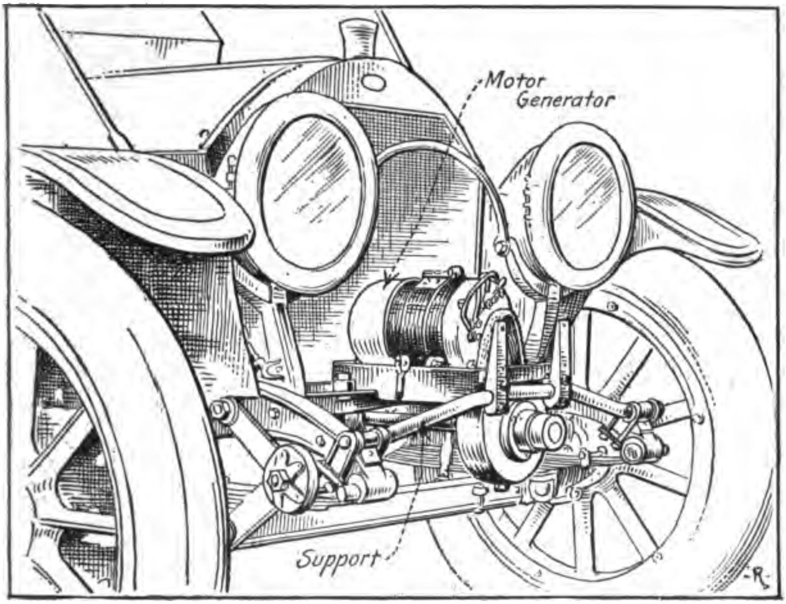


Fig. 212.—Showing Method of Application of North East Universal System to Front of Automobile Chassis.

driving the machine is clearly shown at Fig. 209. A silent chain joins the large sprocket on the engine crankshaft, with the smaller sprocket carried by the motor generator armature shaft. An eccentric adjustment is provided which permits of moving the generator in such a way that the center line is brought closer to or farther away from the crankshaft center line, as conditions demand. This makes it possible to keep the chain always at the

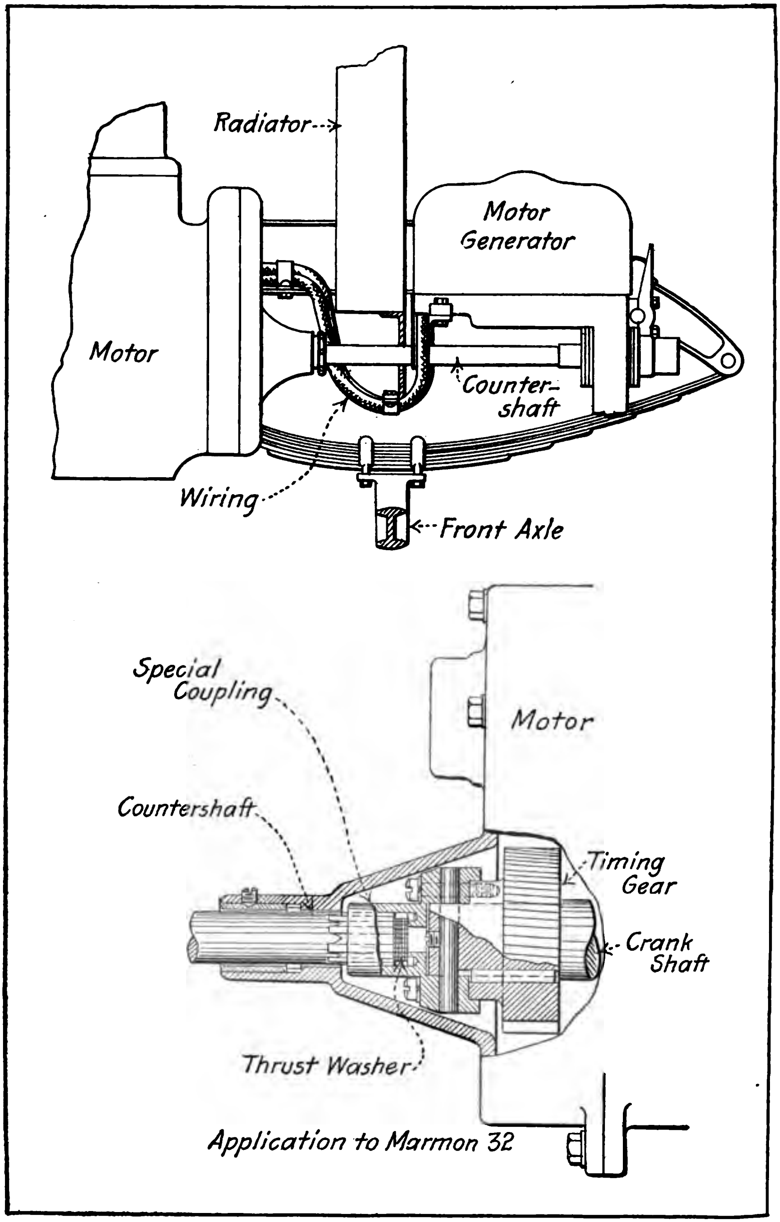


Fig. 213.—Views Showing Method of Driving North East Universal Starting and Lighting System Unit.

proper degree of tension to insure positive drive without whipping, such as results when a chain is run too loosely. A wiring diagram of a 24-volt starting but 12-volt lighting system is given at Fig. 210.

The Northeast motor-generator is said to be a one unit machine in every sense of the word, as it is only one field, one armature, and one set of brushes. The armature has only one winding and

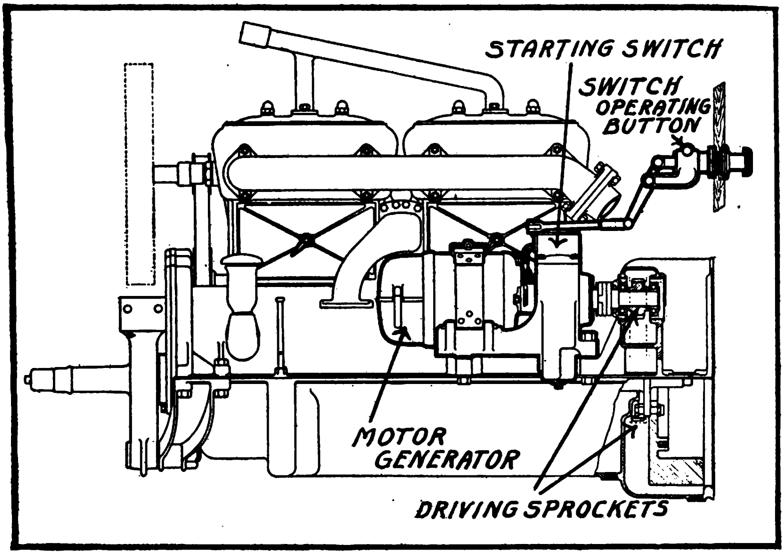


Fig. 214.—How the North East Motor Generator May Be Installed on Four Cylinder Engines.

one commutator, and is the only moving part in the system. The automatic battery cutout is embodied in the motor-generator. This reduces wiring complications and makes the motor-generator a complete machine, contained in one housing. The motor-generator weighs about 40 pounds, and is approximately 6⅝″ in diameter and 10½″ long. It is capable of spinning a 3¾″ bore, four-cylinder engine over 200 r. p. m. In common with most single unit systems, the driving ratio between the motor-generator

and the engine is such that this is usually driven from two and a half to three times the engine speed. A 24-volt 35-ampere hour battery is called for by this system. The motor-generator is connected by only two wires to the storage battery, and it is said that these can be connected without regard to positive or negative polarity. The starting switch also has but two connections to the motor-generator which may be connected without regard to polarity. The system is so designed that no damage will result from operating the starting switch while the engine is running. The connections required are extremely simple as the wiring diagram indicates. The four leads running from the motor-generator are of heavy wire, those going from the storage battery to the machine being of No. 4 cable while those running from the machine to the starting switch are of No. 6 cable. The lamps operate on a three wire system, and while the storage battery delivers 24 volts to the motor-generator but 12 volts is put into any one of the lighting circuits. Fourteen volt lamps are used throughout the system.

The Northeast Universal System has been designed to make possible the installation of this starting unit to old model cars in which no special provisions are made for installing such a system. The sectional view at Fig. 211 shows the method of carrying the motor generator and how it is connected to the engine crankshaft by a countershaft carried beneath the unit. It is designed to go at the front of an automobile, being carried by special brackets which are adapted for almost any standard car. The method of carrying the Northeast Universal System is clearly shown at Fig. 212. The countershaft projecting from the driving sprocket is attached to the engine crankshaft in any suitable manner. A common method of installation is to have the end of the countershaft fit a coupling member that takes the place of the usual cranking dog. The way this is done in case of the Marmon Model 32 car is clearly shown in the sectional diagram at the lower part of Fig. 213. The upper part of this figure demonstrates the simple installation of the unit at the front of the car.

The motor-generator is completely encased, as is the driving chain; there is no opportunity for dirt to collect around the parts

of the mechanism. When applied in this manner the engine crankshaft is turned over in exactly the same way as it would be by the hand crank, which, of course, is replaced by the countershaft assembly driven from the electric machine. The front end of the countershaft is provided with a conventional form of clutch to make it possible to crank the engine by hand in exactly the

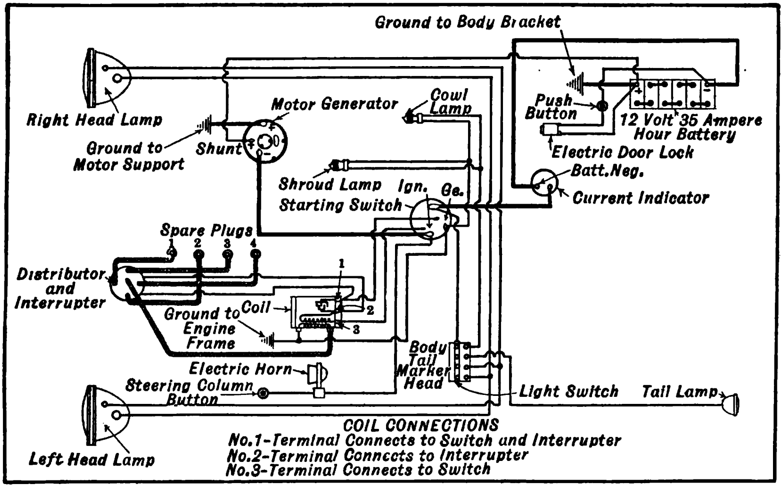


Fig. 215.—Wiring Diagram of Bijur-Scripps-Booth One Unit Starting and Lighting System.

same manner as is ordinarily done after the starting crank is properly engaged. As the starting crank is only used in cases of emergency where the battery has become depleted or where some trouble exists in the electrical machine, it is made detachable so that it can be carried in the tool box. The Northeast Universal System functions in exactly the same manner as the built-in system designed for specific makes of cars.

Bijur Starting and Lighting Systems.—Three types of Bijur Starting and Lighting Equipments are manufactured; the simplest is the single unit, in which one machine acts either as a motor or generator, as conditions demand. The motor-generator equip-

ment is generally chain driven from the crankshaft at a ratio of approximately three to one. This type of machine assumes the function of a generator at about 100 r. p. m., so that with ordinary rear axle ratios the generator function takes place and the battery begins to charge at low car speeds. This machine is provided with a shunt and series winding which act differentially when operating as a generator and cumulatively when operating as a motor. The voltage of the generator is variable as the regulation is for current. At low speeds, the current is maintained sub-

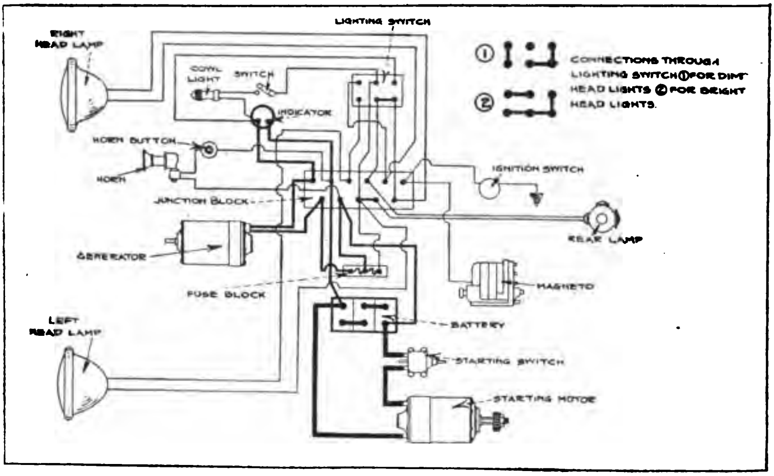


Fig. 216.—Wiring Diagram of Bijur-Apperson Two Unit Starting and Lighting System.

stantially constant, but diminishes at high speed. The regulation is effected by the differential action of the shunt and series field, and also by reason of the fact that the shunt field is connected between one of the main brushes and an auxiliary or regulating brush.

As shown by the diagram at Fig. 215, which shows the electrical equipment on the Scripps-Booth car, no automatic switch is used. Connection between the motor generator and the battery is made with a hand switch, and the motor-generator draws cur-

rent from the battery until the gas motor begins operating under its own power and acquires a speed sufficient to drive the electrical unit at a speed of about 1,000 r. p. m. As this corresponds to an engine speed of about 330 r. p. m., the carburetor throttle is usually adjusted so the engine cannot be throttled down to a speed below the cut-in point of the motor-generator. This is done to eliminate the non-stalling feature and to prevent the battery

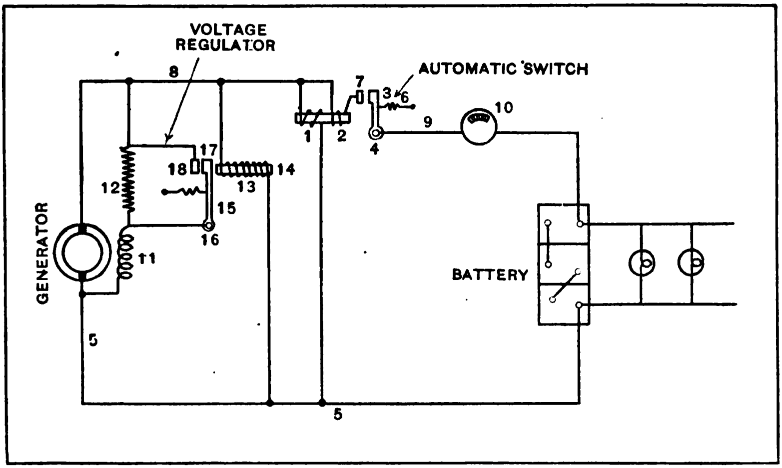


Fig. 217.—Diagram Showing Bijur System of Voltage Regulation.

discharging when a car is left standing idle. The Bijur one unit system is designed to operate on 12 volts.

There are two two-unit systems, one of these having a series starting motor and constant current generator. The other has a constant voltage generator and series motor. Considering the former the constant current generator is a shunt wound machine, the regulation being effected by the shunt field being connected between one of the main brushes and an auxiliary or regulating brush. The units are self-contained and require no separate mounting or connecting of the automatic switch, which is mounted inside the aluminum housing on the commutator end of the machine. These machines are reversible and the connections between

battery and generator may be made without regard to polarity, a very valuable feature. Even if wrong connections are made, the generator will reverse and assume the correct polarity to charge the battery. Each machine is provided with a fuse in the field circuit to prevent injury in case the circuit and the battery is opened. Running the generator under these conditions would result in an abnormal rise in voltage which would damage the field windings except for the protection offered by the fuse. The application of the constant current machine is shown in the wiring diagram of the Appearson system at Fig. 216.

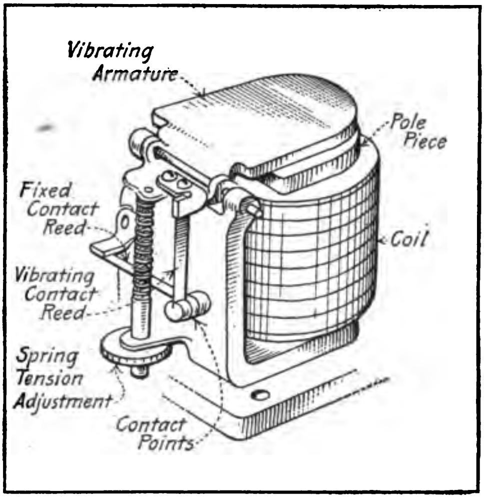


Fig. 218.—View Showing Bijur Vibrator Type Generator Output Regulator.

The constant voltage generators are also shunt wound and regulation is effected by varying the excitation in this winding. The principal circuits for the regulating mechanism are shown in wiring diagrams at Fig. 217. The method of operation is as follows: In series with the shunt winding 11 is a fixed resistance 12, and regulation is obtained by short circuiting this resistance when the generator voltage falls below normal and removing the short circuit when the generator voltage rises above normal. The regulator for performing this operation consists of an iron core 14 with a single winding 13, this winding being connected across the generator brushes. The current in this winding and the resultant pull or magnetic attraction of the core depends, therefore, upon the voltage of the generator. The vibrating armature 15 is pulled away from the core by a spring. When the spring pull predominates, the

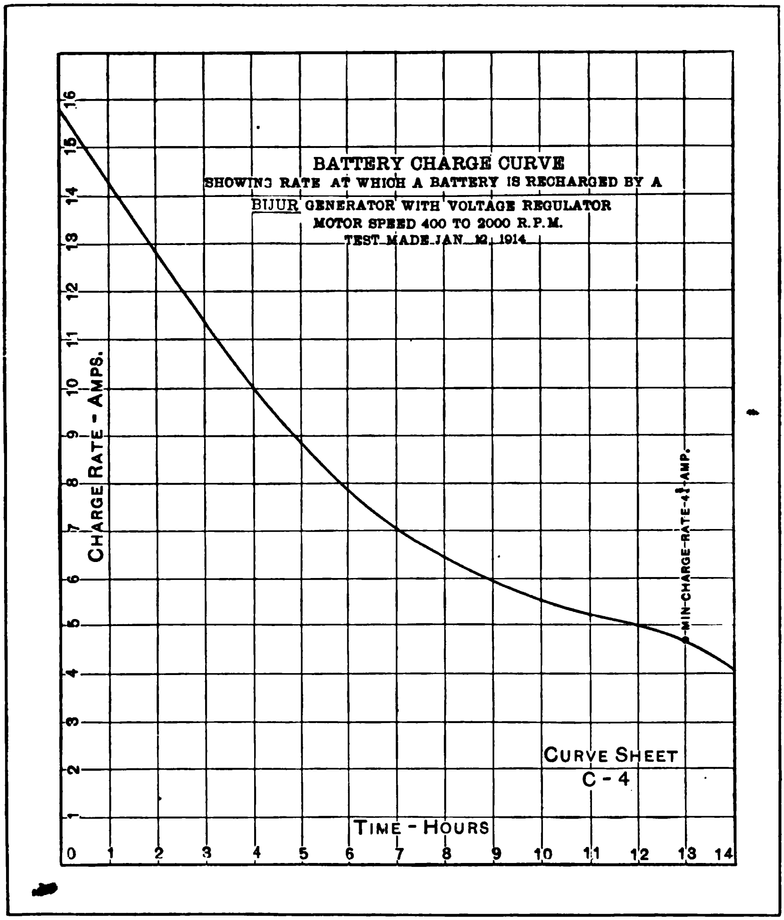


Fig. 219.—Battery Charging Curve of Bijur Generator with Voltage Regulator.

armature moves away from the core, closes contacts 17 and 18, and provides a low resistance path around the resistance 12. The field current increases and the generator voltage builds up; when it exceeds its normal value the magnetic pull of the core predominates and the armature is attracted to the core, thus

again inserting the resistance in the field circuit. One of the main features of this regulator (Fig. 218) is that the contacts which shunt the resistance in series with the field winding in and out of circuit are continually shifting, and do not regularly make contact at the same point. Each contact is mounted on a thin, straight spring which is fixed at the end opposite the contact.

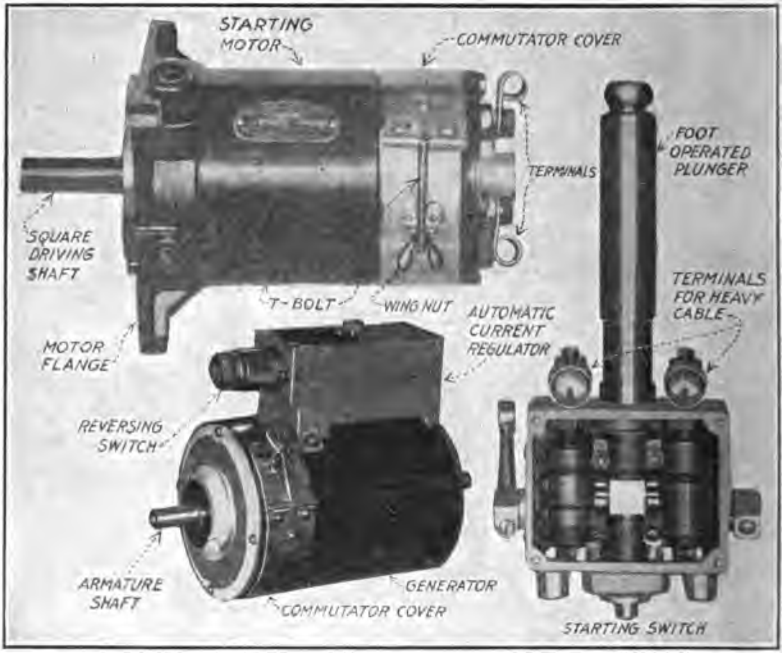


Fig. 220.—Parts of Bijur Starting and Lighting System.

The reeds carrying top and bottom contacts are mounted at a 90 degree angle so that the point of contact continually shifts because of vibration and resulting oscillation of the contact. Continuous vibration is obtained because one of the contact reeds is mounted on a regulator armature which vibrates at a high rate of speed. The shifting of the contacts prevents the formation of minute projections on the negative contact and corresponding re-

cesses in the positive contact, with the result that the contacts never stick.

Wear manifests itself by the positive contact becoming thinner and the negative growing thicker. Periodically, a disconnecting plug is turned in its socket which reverses the polarity of the

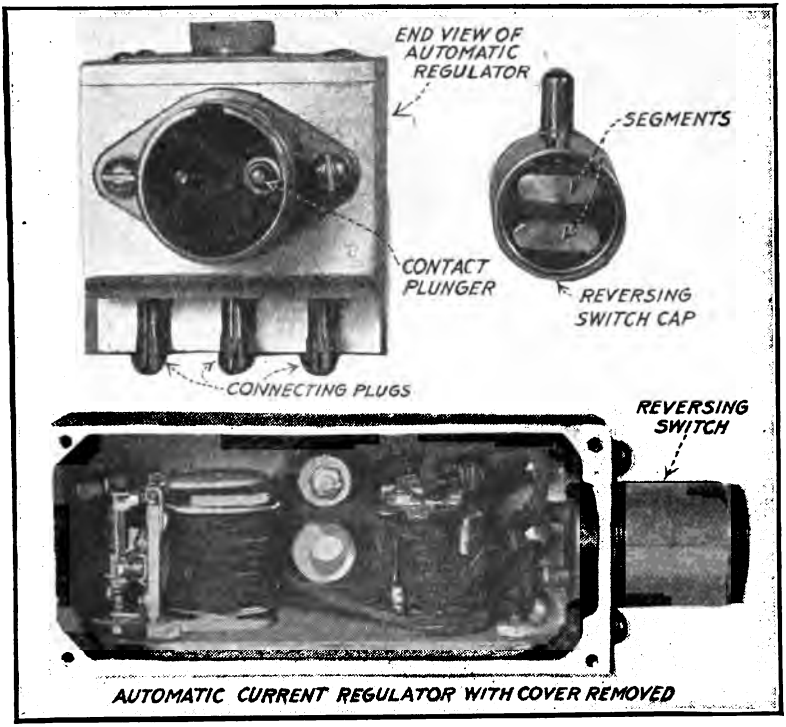


Fig. 221.—View Showing Construction of Bijur Automatic Current Regulator.

contact so that metal which has been deposited from one contact to the other is returned. The regulator vibrations do not take place at irregular or haphazard intervals, but in the order of something like 100 to 150 times per second. The resulting voltage is the resultant of a series of fine ripples above and below the mean value for which the regulator is adjusted. The amplitude

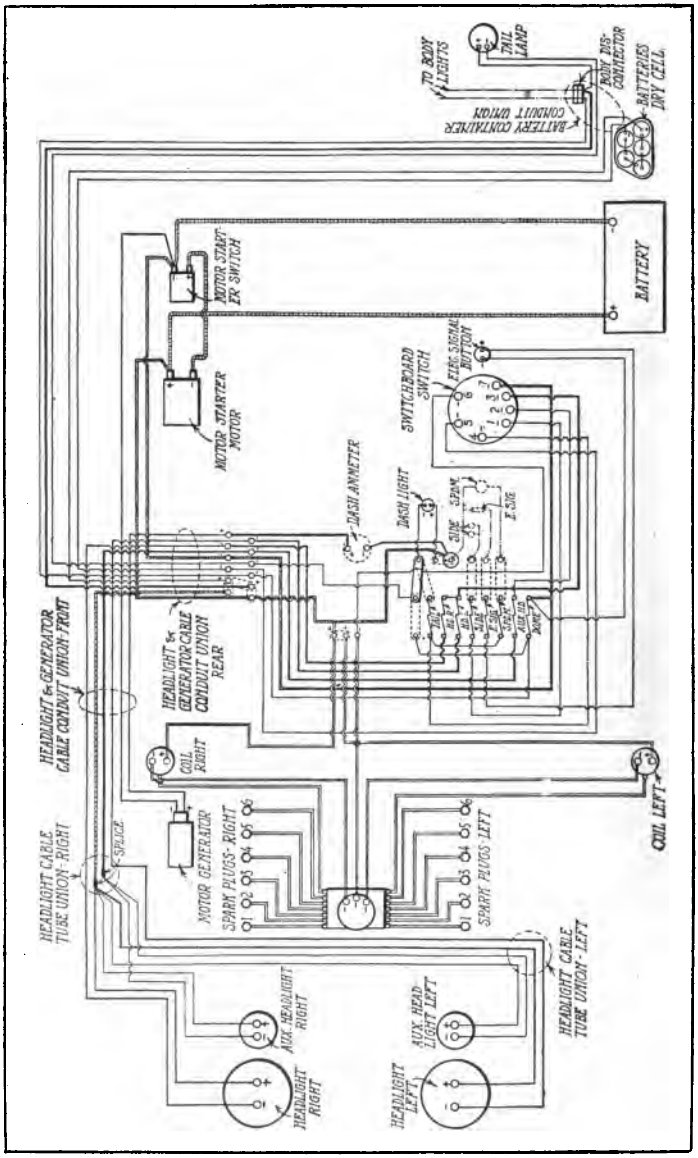


Fig. 222.—Wiring Diagram Showing Circuits of Bijur-Packard Twin Six Starting and Lighting System.

of these waves is very small, and as the frequency is high, satisfactory lighting can be done directly from the generator with no battery connected to the circuit. The generator is connected to the battery, however, and all lights and other electrical devices take their current from the battery terminals. The arrangement of the voltage regulator is such that a discharged battery is charged at a rapid rate while the charging rate tapers off as the battery becomes charged. This is clearly shown by the curve sheet C-4,

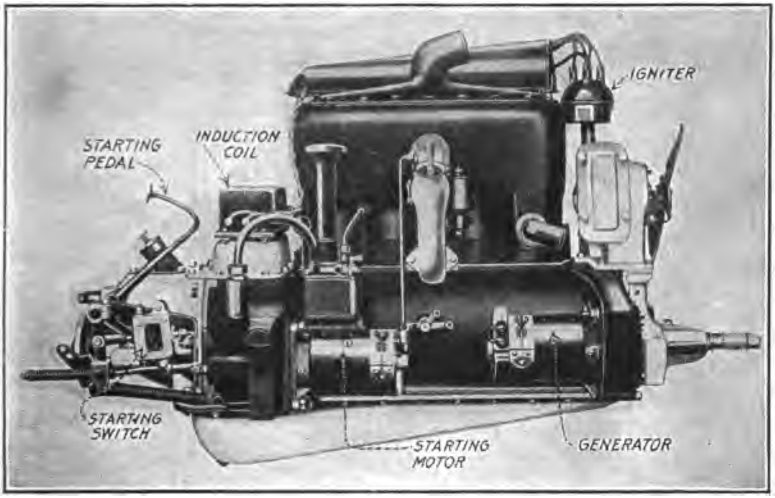


Fig. 223.—Application of Bijur Starting Motor and Generator to Hupmobile Power Plant.

at Fig. 219. It will be observed that at the beginning of the charging process with the battery practically discharged, a charging rate of 16 amperes was obtained, at the end of one hour, but 14.2 amperes were delivered to the battery. At the end of three hours the charging current had tapered down to 11.3 amperes. At the end of eight hours but 6½ amperes was flowing to the battery. In thirteen hours time the minimum charging rate of 4¾ amperes had been reached.

In the constant voltage equipment the automatic switch, voltage regulator and field resistance unit are mounted in an alu-

minum box carried at the top of the generator, as shown in Fig. 220. This box is held in place by a single knurled nut and by three connecting pins or plugs which fit into receptacles in the generator. The two wires leading from the generator are soldered into a connecting plug, which in turn fits into a receptacle of the regulator box. The regulator mechanism can be changed readily by anyone, as no electrical or mechanical knowledge or skill is

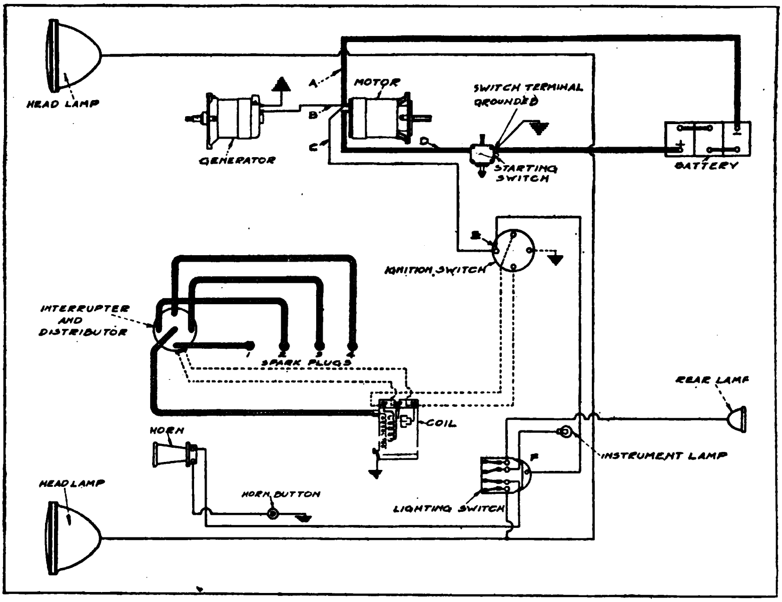


Fig. 224.—Wiring Diagram Showing Circuits of Bijur-Hupmobile Starting and Lighting System.

required. In Fig. 221 the regulator box is shown with the cover removed, which exposes the automatic switch and the field resistance. This also shows an end view in which the connecting pins are shown, and a view of the disconnecting and reversing plugs also. An amperemeter is used in some of the Bijur systems, such as that at Fig. 168, B, which shows the wiring diagram of a Packard six-cylinder car, and in Fig. 222, which shows the system used on the Packard Twin Six. The amperemeter is con-

nected between the generator and the battery and shows only generator output. Whenever the engine is running the meter should indicate, and its failure to do so gives prompt notice that there is trouble.

The Bijur two unit systems are subjected to a division on account of the starting motors that are used, there being two types, geared and direct acting. In the geared type, double reduction gears are included between the starting motor and the engine flywheel. An over-running clutch is included in the gearing. In the direct acting type the motor pinion meshes directly with the flywheel teeth, the double reduction gearing and roller clutch being omitted. The motor has a square shaft and a pinion having a correspondingly broached hole can be moved horizontally on the shaft into and out of mesh with the flywheel. The motor shown in Fig. 220 is of this type. The direct acting motors can also be used in connecting with the Bendix drive in which a screw shaft carrying a weighted pinion provides for automatic shifting. The standard voltage for the Bijur two unit equipments is 6 volts, though these have been manufactured in 12, 16, and 18 volt systems.

A variety of starting switches are manufactured, these usually being selected according to the form of starting motor used. The usual type is provided with a preliminary contact which connects the battery and starting motor through a resistance located inside of the switch. This preliminary contact is made just prior to meshing the starting gears and flywheels and causes the motor to rotate at low speed and with little power, so that proper meshing of the gears is insured without any liability of stripping them. The switches may be direct acting or indirect acting. That shown at Fig. 220 is a direct acting switch having a foot-operated plunger which is intended to project through the floor board. Depressing this heel button makes the two switch contacts, and also shifts the gears into mesh with the flywheel through a mechanical interlock provided for that purpose. In the indirect acting type the starting switch is connected through a system of linkage to a starting pedal located at the driver's seat. Switches are also made in which no preliminary contact is used. The method of meshing the gears

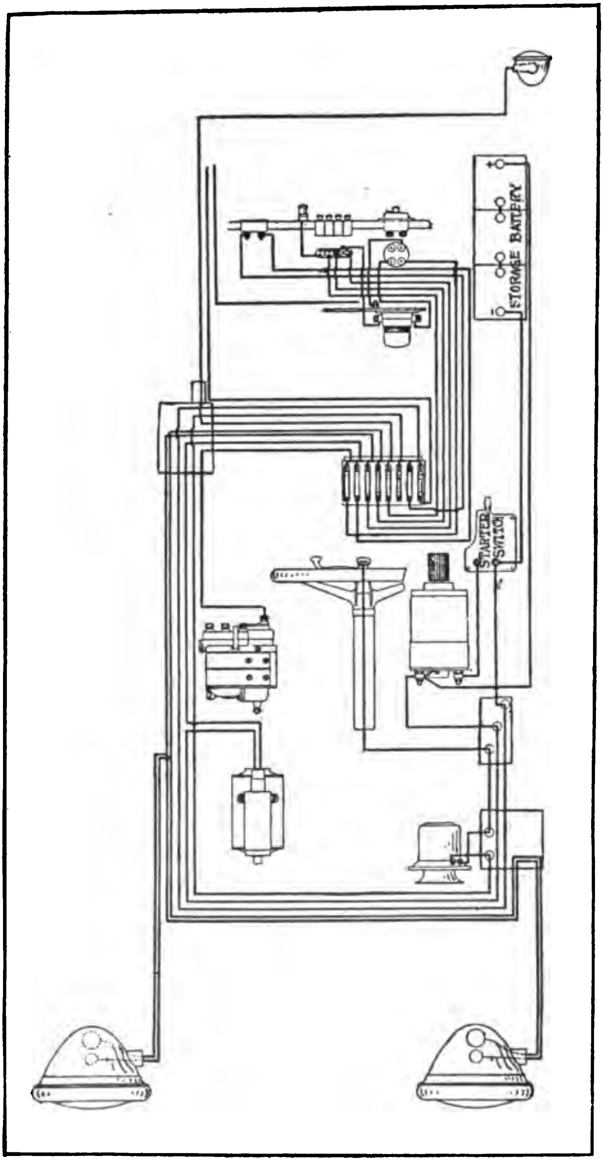


Fig. 225.—Wiring Diagram of Bijur Starting and Lighting System Used on Winton Six Model 21-A.

with the single contact switch is illustrated at Fig. 160 in the preceding chapter. The mounting of the generator, motor and starting switch for the Hupp Model N car is clearly outlined at Fig. 223. The complete wiring diagram for the Hupp, which shows the manner in which the various units are connected together, is shown at Fig. 224. In this system ignition is by the battery through the conventional short contact timer and distributor and induction coil. In the Apperson System, outlined at Fig. 216, a high tension magneto is used for ignition. This is also the type of ignition used in connection with the starting and lighting system of the Model 21-A Winton Six, shown at Fig. 225.

Bijur-Packard System.—The self-starting and lighting system, Fig. 168, B, used on the 1915 six-cylinder Packard, is manufactured by the Bijur Motor Lighting Co. In this system the starting motor and generator are separate units. The starting circuit is simple, consisting of a motor connected directly to the battery and operated by closing a starting switch.

In the generator circuit the principal parts are: The generator; an automatic switch for breaking the circuit when the speed of the generator becomes so low that the battery current would discharge through it, and a voltage regulator of the vibrator type. A study of the wiring diagram shows that the automatic switch has two coils, a voltage coil of high resistance connected across the wires leading to the battery and a current coil in series with the generator and battery. The action of this coil is such that as the armature speed increases and the voltage becomes greater, the magnetism generated in this coil attracts a small steel arm, thus completing circuit between the battery and the generator. Current then flows to the battery and lights.

On the other hand, as the speed of the generator decreases, its voltage becomes less and finally a point is reached where the current begins to flow back into the generator. This reversal of flow produces a magnetic field in the series coil of the cutout which opposes the field produced by the voltage coil, until finally the attraction of the latter for the steel arm that completes the circuit is entirely overcome and then the arm, impelled by a spring, breaks contact.

The voltage regulator operates on the vibrator principle, and is designed so that when the voltage becomes higher than the predetermined amount the vibrator throws a resistance into circuit that reduces the amount of current flowing through the field, as has been previously described. Nothing in the wiring is unusual and the diagram may be easily followed in view of the complete explanation previously given of the Bijur systems.

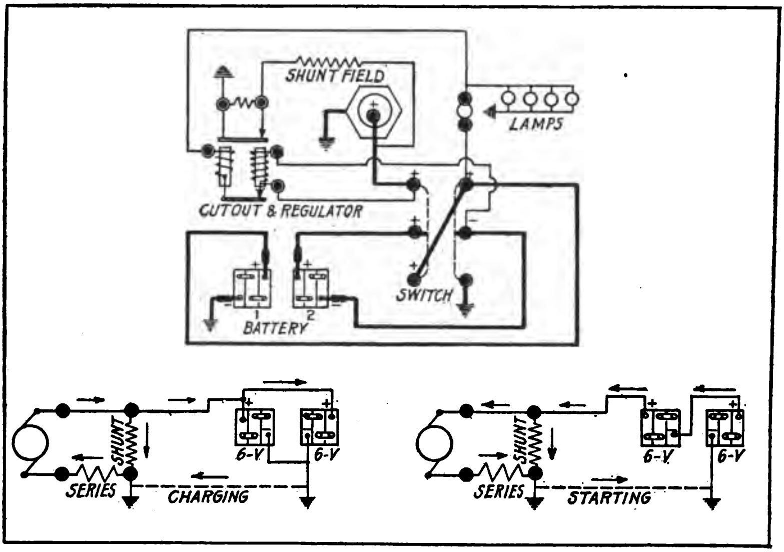


Fig. 226.—Simplified Wiring Diagram Showing Action of Simms-Huff Starting and Lighting System.

The Simms-Huff Single Unit System.—The operation of this one unit system differs from the Dyneto in that the wiring arrangement is so designed that the non-stalling feature is eliminated. The simplified wiring diagram which is presented at Fig. 226 shows that this system operates on the one wire method, and that the wiring is such that a 12-volt series battery arrangement is used in starting while the 6-volt parallel charging scheme is followed. The starting switch, which may be either foot- or hand-operated, automatically controls the battery connection and pro-

vides a wiring scheme for the lighting circuit which insures healthy battery action and makes for minimum fluctuation in candle power when the motor, for instance, is being cranked with the lights burning or at the other extreme when the engine is raced. Through the inherent winding arrangement, when the motor-generator is used for starting, it automatically becomes a 12 volt cumulative compound motor which on being driven by the starting of the engine becomes a differential dynamo and charges the batteries at a predetermined rate which can be varied by a single regulator adjustment that is easily made.

The small diagrams in Fig. 226 show the inherent winding arrangement which automatically accomplishes these results. On

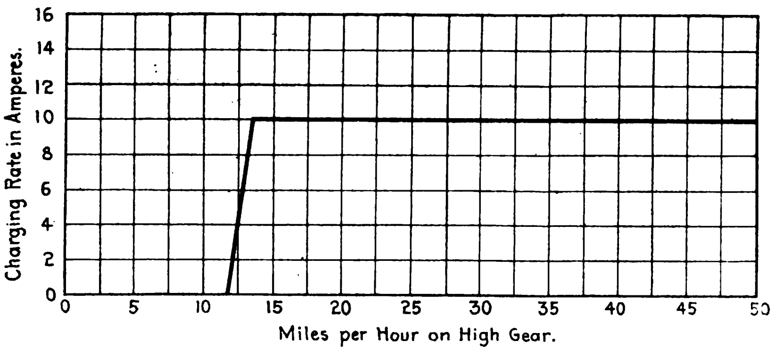


Fig. 227.—Curve Showing Current Output of Simms-Huff Generator.

examining the directions of the arrows it will be seen that the current which the arrows represent flows in the opposite direction in the series field when charging than it does when starting. The action of the powerful field winding is to assist the motor when starting by increasing the strength of the magnetic field and to weaken the field strength of the dynamo when charging and prevent an overcharge at high speed. In this manner it automatically assists the regulation of the charging current delivered to the battery. The charging current increases from zero to its maximum with a very small increase in car speed. This is clearly shown in the graphical diagram at Fig. 227, as this outlines the

rate of charge in amperes corresponding to car speed in m. p. h. with the ordinary gear ratios and wheel sizes. This curve illustrates a sudden rise in current which starts at a speed of about 12 m. p. h. and which reaches its full value of 10 amperes before the speed is increased over 13 miles per M. P. H. From this point on the generator delivers a current having a value of 10 amperes regardless of engine or car speed.

The construction of the unit is clearly shown at Fig. 228. The yoke and field winding assembly shows clearly the hexagon yoke

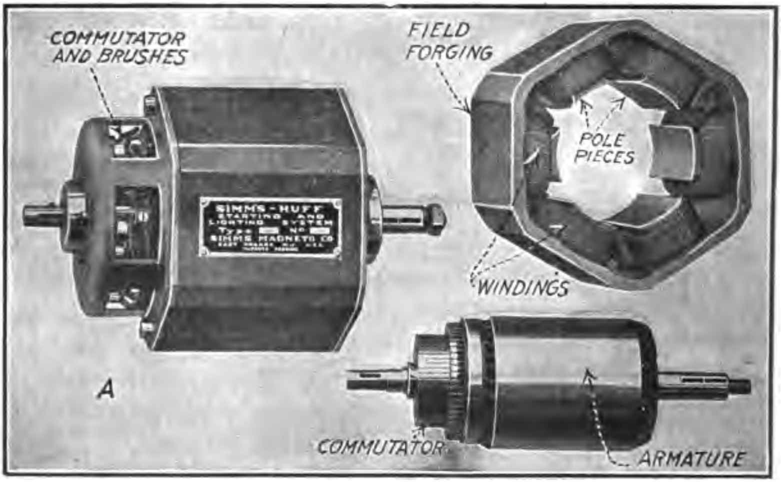


Fig. 228.—Views Showing Construction of Simms-Huff Motor-Generator.

which makes it easy to mount the device on the engine and at the same time gives a maximum field strength with economy in space and weight. The armature is an iron clad drum winding and is perfectly balanced. The complete unit with the cover removed from the end to permit of ready inspection of commutator and brushes is also outlined. The wiring diagram at Fig. 229 shows the application of the complete system to the Maxwell car while the method of attaching the generator to the engine is clearly depicted at Fig. 230.

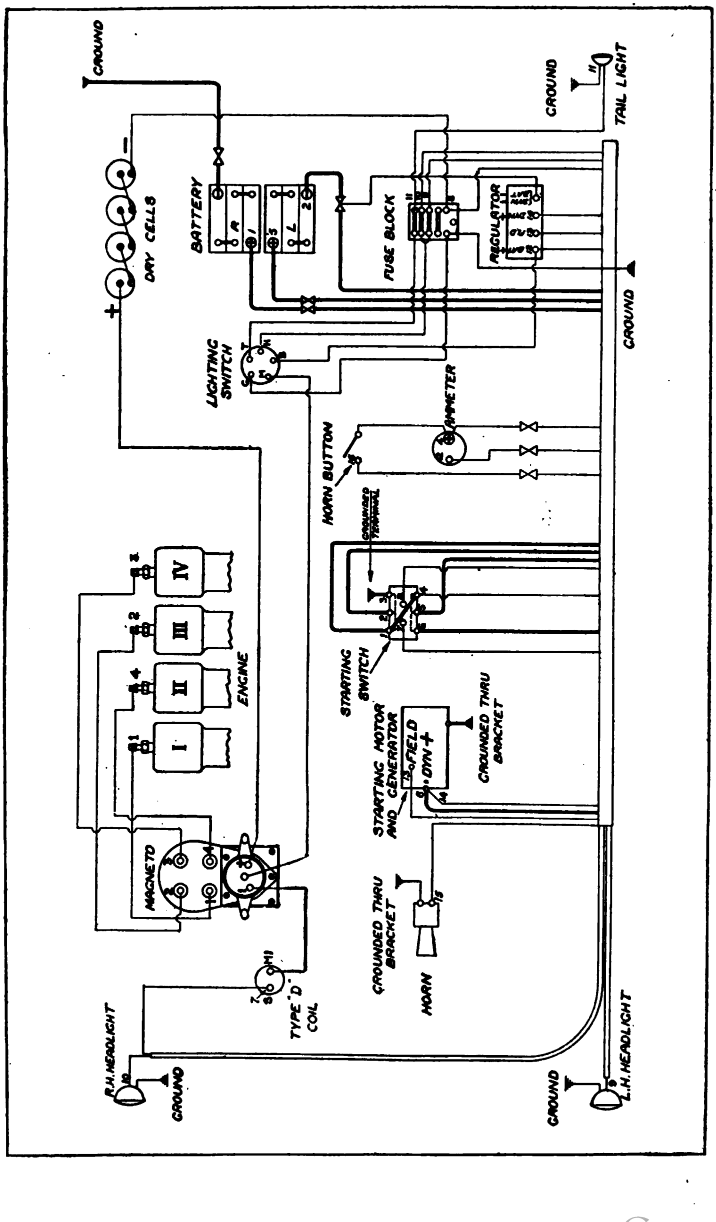


Fig. 229.—Complete Wiring Diagram of Simms-Huff Starting and Lighting System Used on Maxwell Automobiles.

The unit is connected to the gas engine through a gear reduction in the conventional manner. The starting is accomplished by depressing a starter pedal which provides an interlock between the starting switch and the gear reduction. When contact is made at the starting switch the current flows through the armature and field windings, these drawing approximately 40 amperes from the storage battery to start a 4 cylinder car of 30 H. P. The cranking speed depends upon the ratio of gear reduction and condition of the motor. The starting switch construction is bolted to the left side of the transmission case and the interior arrangement

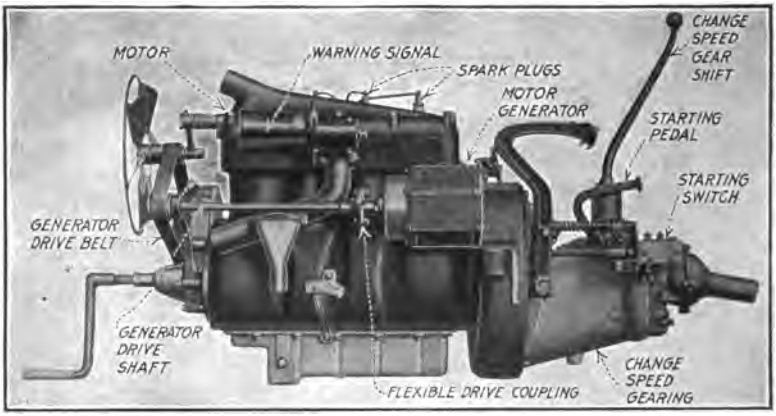


Fig. 230.—How the Simms-Huff Motor-Generator is Installed on the Maxwell Engine.

is such as to automatically connect the two halves of the storage battery in series when starting which means a current of 12 volts, or in parallel when generating, which means a charging current of 6 volts. As applied to the Maxwell engine the machine is geared to the flywheel by a sliding pinion when starting and is driven by the fan belt from the front end when generating.

In common with all systems involving the use of the generator and storage battery together and not having the non-stalling feature, it is essential to provide some means of preventing the bat-

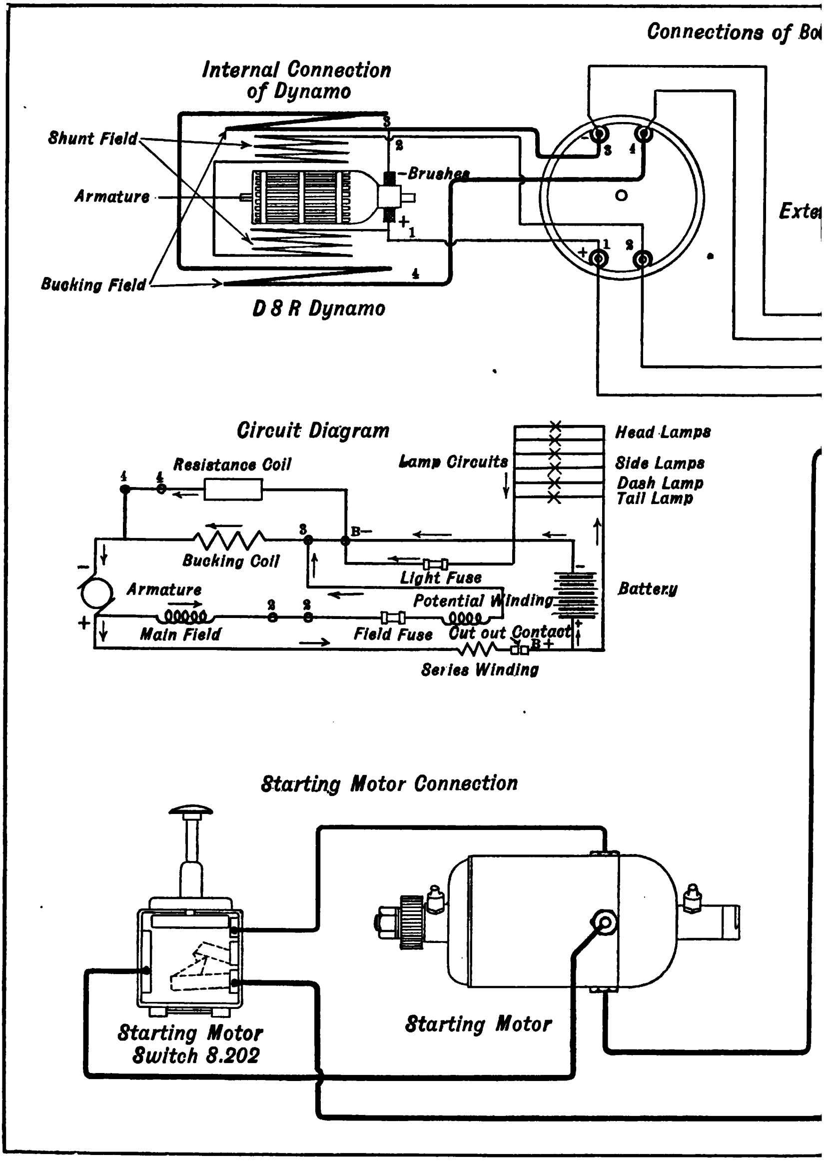
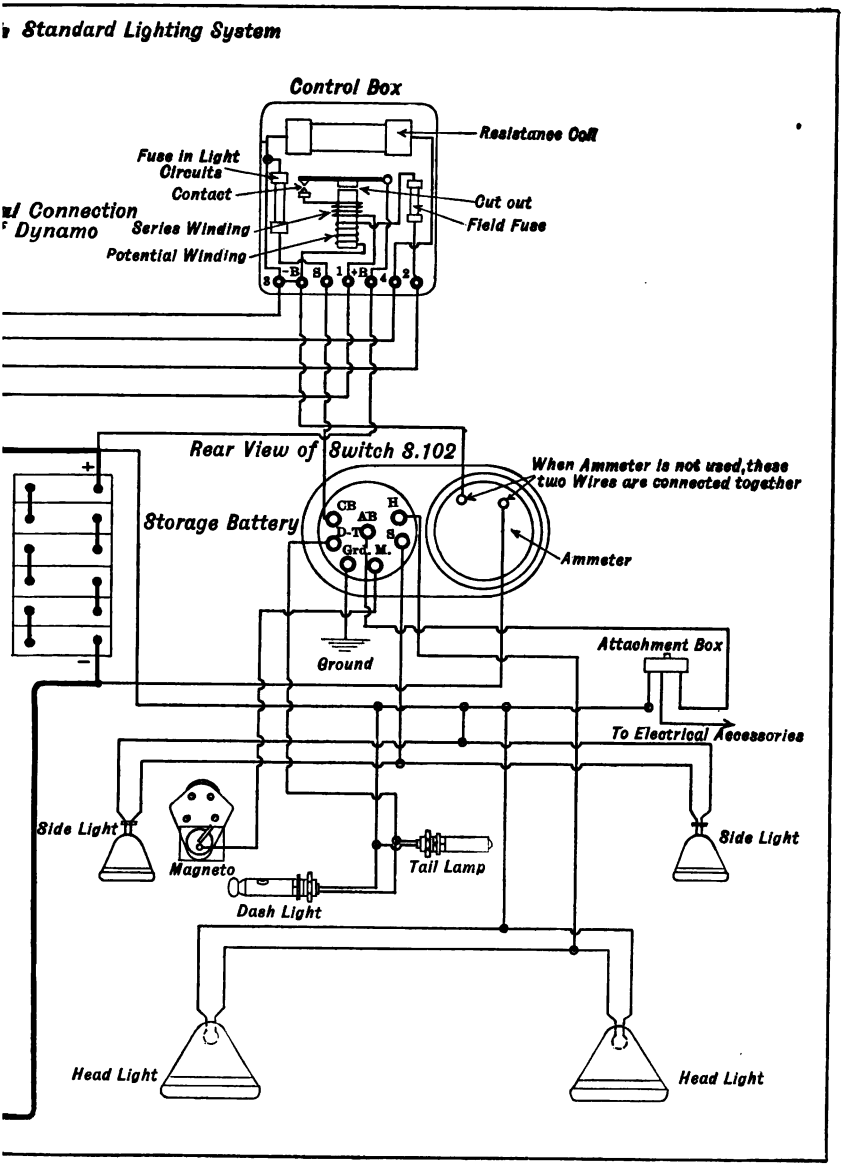


Fig. 231.—Wiring Diagram Showing All Connections of Bosch S



andard Lighting System with Rushmore System Starting Motor.

tery from discharging into the generator when the engine is at a standstill or whenever the terminal voltage of the generator is less than that of the battery. To attain this object a cut-out relay is inserted in the charging circuit and is equipped with a compound shunt and series winding. As the generator voltage builds up, the current through the shunt winding closes the cutout and permits the generator to charge into the storage battery. When the generator voltage falls below that of a storage battery the battery current passing through the series field winding of the cutout automatically demagnetizes the core and the circuit leading to the generator is opened, this preventing discharge of the battery. The cutout and regulator serves the double purpose of a cutout relay and regulation independent of belt tension. It is essentially two distinct relays, one serving to regulate the amount of charge from the generator to the storage battery regardless of belt tension. To accomplish this last step the shunt field of the generator is brought into the regulator at the terminal marked "F. L. D." by means of vibrating contacts and additional resistance is automatically cut in the dynamo field when the voltage rises and cut out when the dynamo voltage lowers. In this manner the dynamo is made to hold to a practically constant current output which means a constant charge into the battery. It must be understood, however, that the belt tension must be sufficient to give the generator proper speed for producing a charging current, as the regulator

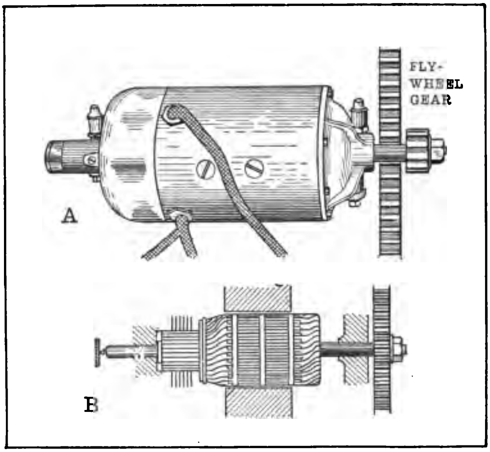


Fig. 232.—Diagram Explaining Automatic Pinion Shift of Bosch-Rushmore Starting Motor.

is only intended to prevent excessive current generation. An adjustment is provided by means of a slotted segment and bolt on the fan support for varying the belt tension.

The Bosch-Rushmore System.—Bosch-Rushmore Systems are made in two forms, the chief difference being in the generator construction. One form is of the current regulation type, while the other operates on the voltage regulation principle. The complete wiring diagram given at Fig. 231 shows all connections of the Bosch Standard Lighting and Starting System. A supplementary circuit diagram is presented to show the methods of current regulation. This is accomplished by a ballast or bucking coil which interposes resistance to weaken the magnetic field and keep the generator output reasonably constant. The starting motor is of the well-known Rushmore pattern which has the automatic gear meshing feature produced by a laterally shiftable armature. The method of operation is outlined at Fig. 232. The starting motor armature is normally pushed over to one side of the motor field, the position being such that the starting pinion carried on the armature shaft is out of mesh with the large flywheel gear. A 12 volt battery is used in connection with this system. The first movement of the starting switch plunger draws the armature into the field and against the resistance of the coil spring that act to unmesh the gears. Further movement permits the starting current to flow through the starting motor windings, which of course, turns the engine over after the pinion has been positively meshed with the flywheel gear.

Some of the parts comprising the Bosch System are shown at Fig. 233. The Bosch De Luxe System, which is the electrical equipment of the Model 6-41-1915 Marmon car is shown at Fig. 234. The application of the ignition generating and starting units to the 6-41 power plant is outlined at Fig. 235. The generator and ignition magneto are placed on the same side of the motor while the starting motor is placed on the valve side and is carried by a substantial bracket in such a position that the pinion on the armature shaft will engage promptly with the starting gear cut on the flywheel. The application of the various control units of

the De Luxe system on the car may be readily ascertained by inspecting the views at Fig. 236. The ignition function is normally

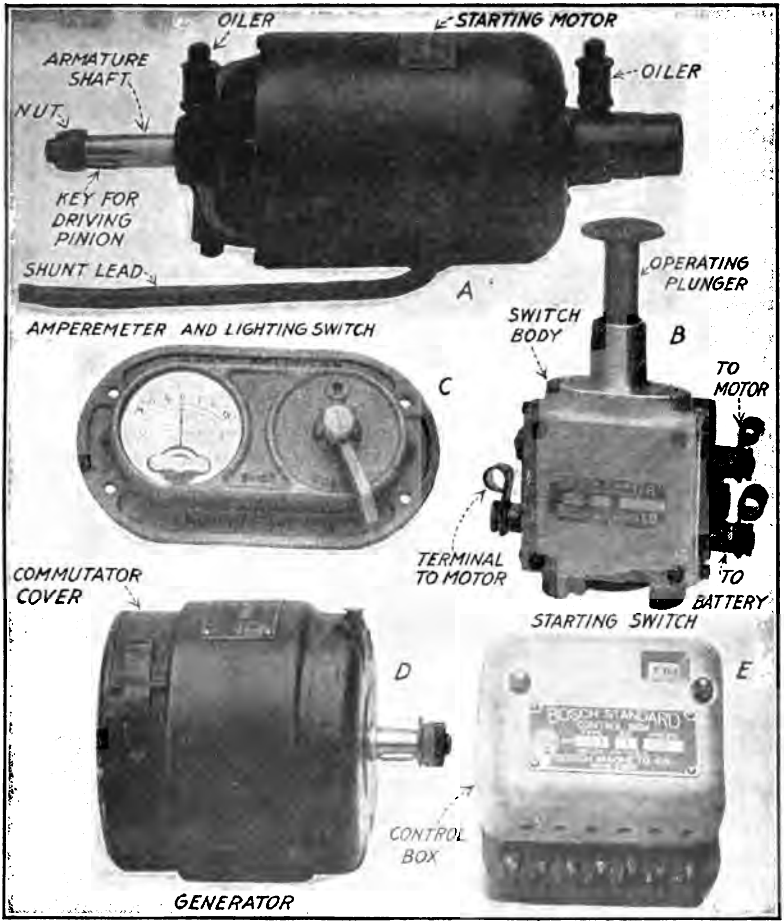


Fig. 233.—Parts of the Bosch-Rushmore Starting and Lighting System.

independent of the lighting and starting system as a Bosch "Vibrating Duplex" magneto is employed. The only time the battery

is called upon to contribute to the ignition is when the engine is cranked over very slowly, when it produces a spark through the Duplex coil to facilitate starting. A special enclosed type of coil is mounted under the dash cowl, this is in series with the battery and also with the primary winding of the magneto. With this system only a single wire runs to the magneto, and no additional timing device is necessary. When the ignition switch is on battery position the coil receives current from the storage battery, this augments the natural action of the magneto and gives a hot spark even at very low speeds. The coil is connected so that it will operate over a wide range of voltage and will provide positive ignition even though the starting motor will barely turn the engine over on account of a depreciated battery.

When the starter pedal is released after the engine starts the ignition switch should be moved to the "MN" or the magneto position in order to obtain straight magneto ignition. A 12 volt starting and lighting circuit is employed, all units, including the lamps being of this voltage. The one wire system is employed, the positive battery connection being grounded through a fuse. Instead of relying upon local grounds for each connection an armored cable is used which not only serves to protect the wires but the metallic armor makes a positive return. An ingenious connection is provided for joining the various cables, so that not only a fine mechanical joint is obtained but at the same time a good electrical contact results. The generator is a simple shunt wound machine obtaining all regulations by means of external appliances. The rotating armature, which is carried on ball bearings, is provided with a fan for purposes of ventilation. An automatic reverse current relay in the switch and meter box on the dash opens the battery circuit whenever the generator is not running, thus preventing an escape of battery current through the generator.

A voltage regulator provides for the constant maintenance of the correct electro-motive force at all times. The regulator is so constructed that it will maintain a fixed voltage while carrying the entire lamp load at low motor speed and will not vary when

a change is made either in speed or load. The regulation means must also take care of the internal conditions of the battery. If

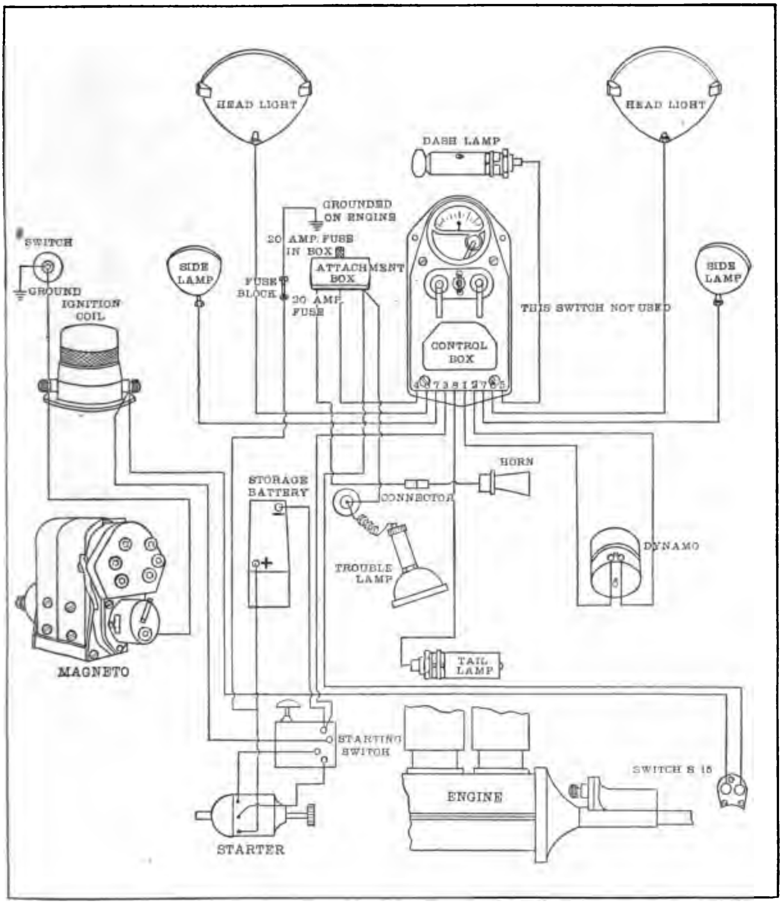


Fig. 234.—Wiring Diagram Showing Relation of Parts of Bosch-Rushmore Starting and Lighting System Used on the Marmon Six-41 Automobile.

the battery is totally discharged the regulation must be such that a tapering charge is given. The amount of current flowing to the

battery must become less as the charge nears completion. The regulator requires absolutely no attention as there is practically

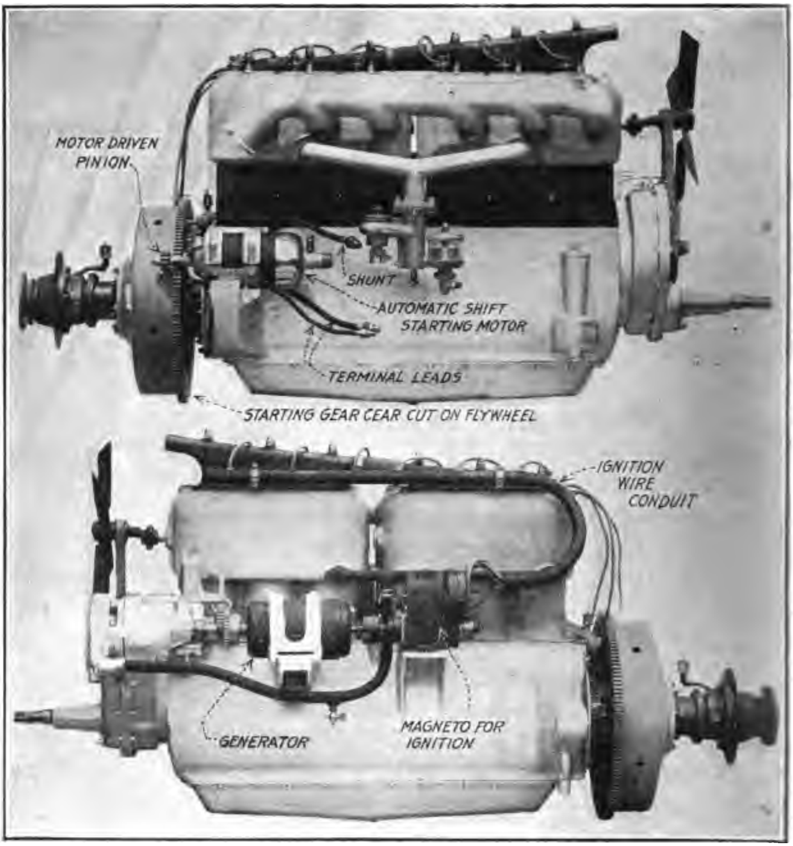


Fig. 235.—Method of Installing Bosch-Rushmore Starting Motors on Marmon Engines Shown at the Top. Location of Ignition Magneto and Current Generator Depicted at the Bottom.

nothing to get out of order. The generator terminals, lamp and battery wires all lead into the switch box on the dash, which contains, besides the regulating devices, the volt-ammeter and the

lighting switch. The volt-ammeter permits a constant check on the operation of the system. When the control lever is thrown to the left the needle should show 12 to 15 volts when the engine is running rapidly or about 12 volts when the engine is stopped. When the lever is turned to the right to indicate amperes the current discharge when engine is not running is about 8 amperes for the full

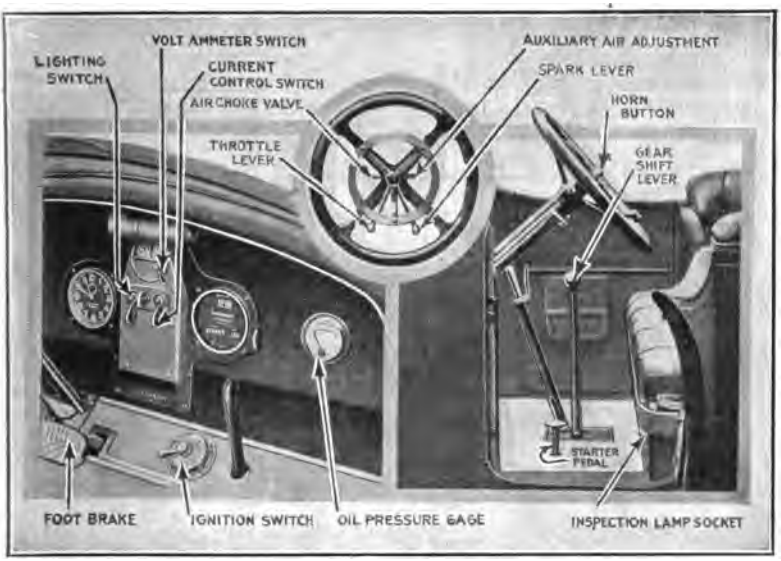


Fig. 236.—Views Showing Control Members of Bosch-Marmon Starting and Lighting System.

lamp load, and will vary from this point to 8 or 10 amperes charge with a rapidly running motor, no lamp load and a partially discharged battery. Whenever the needle indicating amperes is to the right of zero the battery is being charged. Whenever the needle is to the left of zero current is being drawn from the battery. The starting motor (Fig. 237) is strapped firmly to the crank case and is a simple but powerful series wound motor having a movable armature. The motor is a plain bearing type, so oil

must be placed in the oilers periodically. The instructions given for the care of storage batteries in connection with other systems apply just as well to the Bosch System.

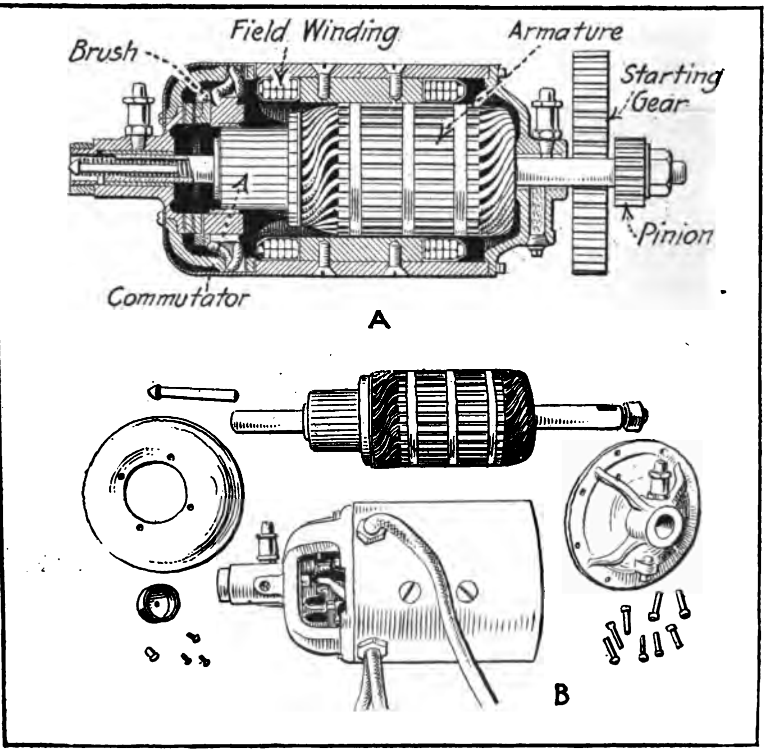


Fig. 237.—Sectional Diagram at A Shows Internal Construction of Bosch-Rushmore Starting Motor Which is Shown Dismantled at B.

Remy Starting, Lighting and Ignition Systems.—The Remy Systems are made in a number of patterns, most of these operating on the two unit principle. The Remy System used on the Oakland Model 32 uses the No. 166 ignition generator and the model No. 114 starting motor. The model 166 ignition generator is similar in

construction to that shown at the left of Fig. 239 except for the mounting of the cutout relay which is placed at the back of the instrument, instead of on a bracket close to the coil. The parts comprising the Oakland starting and lighting system are clearly shown in Fig. 240, all circuits which operate on the one wire principle being clearly shown. The ignition generator is a low speed, 6 volt machine of the four pole shunt wound type and is driven at one and one half times crankshaft speed. The maximum current output is obtained at moderate car speed and it generates ample current to keep the battery fully charged. The control of the current output is automatically obtained by a vibrator type of regulator. The armature is a slotted drum type and is carefully balanced in order to minimize bearing stresses. The ignition distributor, which embodies the distributing mechanism and circuit breaker is simple in design and is positively driven from the armature shaft. The ignition coil is also mounted on the generator in order to simplify wiring.

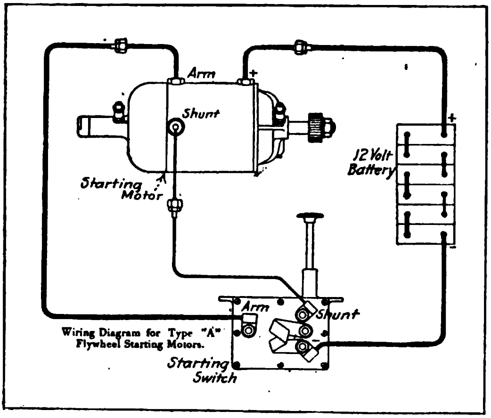


Fig. 238.—Wiring Diagram for Type A Bosch-Rushmore Starting Motor.

The starting motor is a four pole series wound machine using the Eclipse-Bendix automatic transmission to connect the motor with the engine. In this type the extended armature shaft carries a hardened steel sleeve upon which a triple worm gear is cut. Operating upon this sleeve is a hardened steel pinion having a lateral travel of about 1½″. When the current is supplied to the starting motor, the armature, being free, begins to revolve at a high rate of speed. The pinion, by reason of its property of inertia

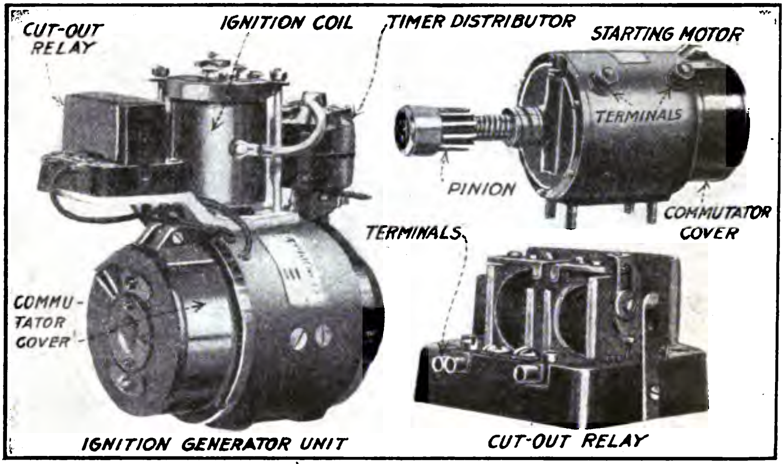


Fig. 239.—Parts of Remy Two Unit Starting, Lighting and Ignition System.

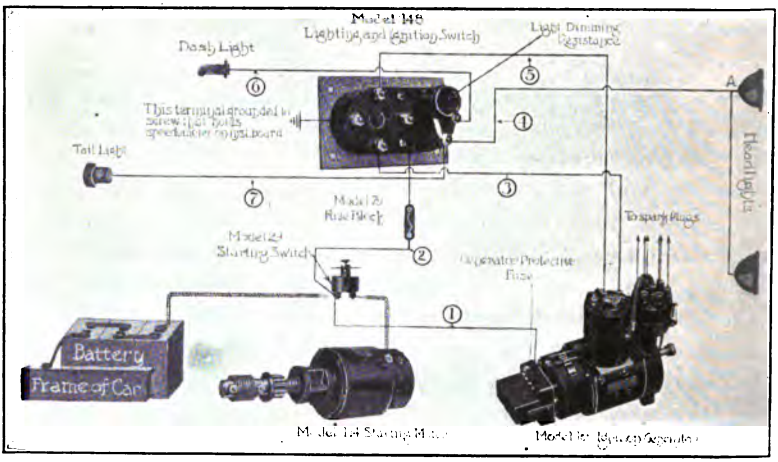


Fig. 240.—Arrangement of Parts of Remy Two Unit System Used on Oakland Model 32 Cars.

tends to stand still and is drawn by the worm along the sleeve and into mesh with the gear which is cut upon the flywheel. The starting switch is a very simple fitting, designed especially for use with the automatic pinion shift. The combination lighting and ignition switch has two removable keys, that at the left controlling the lighting service and on the right the ignition circuit. The lighting switch has three positions. One in which all lights are off, a second in which the dash light is bright and the tail lights

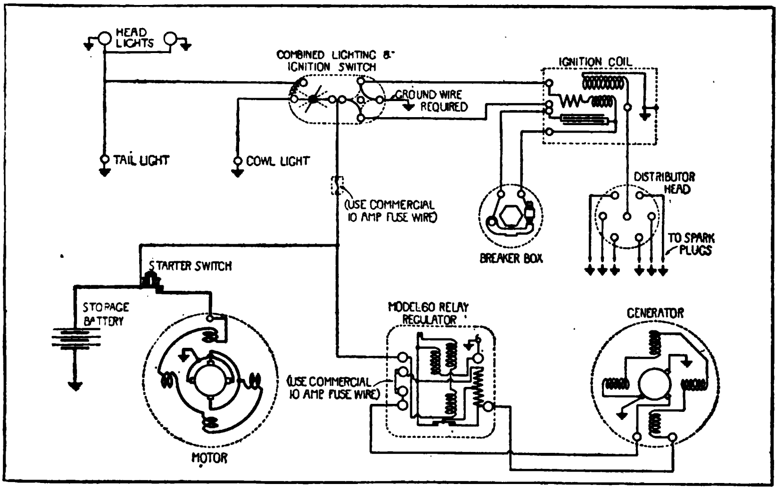


Fig. 241.—Wiring Diagram Showing Circuits of Remy-Oakland Starting, Lighting and Ignition System.

and head lights are dim and a third position in which all lights are bright. The cutout relay regulator used in connection with this system is also shown at Fig. 239 with the cover removed. The cutout operates on the same principle that has been previously described and acts merely to prevent discharge of the battery through the generator when the engine is not running. The contact points of the cutout are held together only as long as the voltage of the generator is in excess of the battery voltage.

The regulator portion consists of an electro magnet, an arm

operating on hardened bronzed pivots; two sets of contact points, two of which are mounted upon springs and a resistance unit. When the generator is running at a speed lower than that required for maximum output the regulator contact points are held together by a spring under the arm and the current supplied to the generator field passes directly through these points. As soon, however, as the speed of the generator increases to such a point that the output rises above the predetermined maximum, the charging current which is flowing through the coil on the electro magnet energizes it to such an extent that it pulls the arm down. This pulls the contact points apart and forces the field current which had heretofore been passing through these points to pass through the resistance unit. The resistance decreases the field current which in turn diminishes the output of the generator. As this reduces the energizing effect of the electro-magnet, the spring forces the contact points together and the resistance is cut out of the field circuit. A continuous repetition of this operation sends a pulsating current to the generator field and holds the output of the generator at practically a constant value. For the purpose of protecting the generator, an easily accessible fuse is fitted to the relay regulator base. In case the battery should become disconnected, either through accident or neglect, this fuse will burn out, rendering the generator inoperative and damage proof. The wiring diagram presented in technical form of the Remy-Oakland 32 system is shown at Fig. 241. In view of the explanations that have been previously give no difficulty should be experienced in tracing the various connections, especially if the wires are compared with those on Fig. 240, which show the connections to the units comprising the system but not the internal connections of the units.

Another Remy Starting and Lighting System uses the model 165 ignition generator which is shown at Fig. 242. This includes a standard magneto distributor and circuit breaker and forms a single unit from which current for lighting, ignition and starting is obtained. The ignition generator carries the full lamp and ignition load of approximately 7½ amperes at a car speed of from 10 to 12 miles per hour. The output of this generator is regulated by the well known third brush system. At low speeds the magnetic

flux of a generator is evenly distributed along the basis of generator pole pieces, but at high speeds it becomes destroyed. The third brush which supplies current to the generator field winding is so located in relation to the main line brush of opposite polarity that this distortion of the magnetic flux reduces the current which it supplies to the field winding. This decrease of field current naturally causes a decrease in the output of the generator and prevents it from attaining a harmful value. The only external regulating device used is a reverse current relay to prevent the storage battery discharging back through the generator. The current for ignition is taken from the storage battery and is passed through the induc-

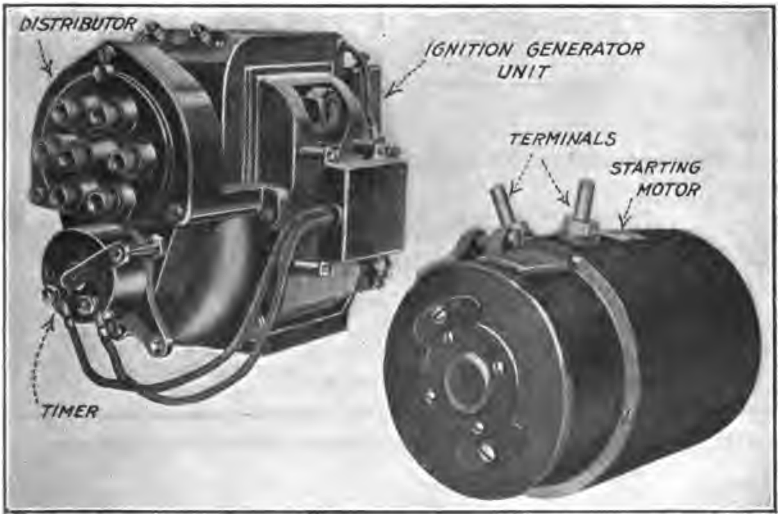


Fig. 242.—Views Showing Remy Ignition Generator Unit and Another Form of Starting Motor.

tion coil before it is delivered to the distributor of the generator. The complete Remy lighting, starting and ignition system used on the Reo car is shown at Fig. 243. This diagram is especially valuable inasmuch as it not only shows all circuits but also the size of the wires needed to connect the various units together.

In connection with the Remy-Oakland system it is stated that

the ignition switch must be placed in the "off" position when the engine is not running. If it is let in the "on" position when the engine is not running, current from the storage battery will be dissipated in the ignition coil and will result in battery exhaustion. The battery should never be disconnected while the engine is running as this will cause a generator protective fuse on the relay regulator base to burn out. In case this fuse should burn out and an extra one is not available it is possible to proceed without a fuse as the charge in the battery will operate the ignition, lamps

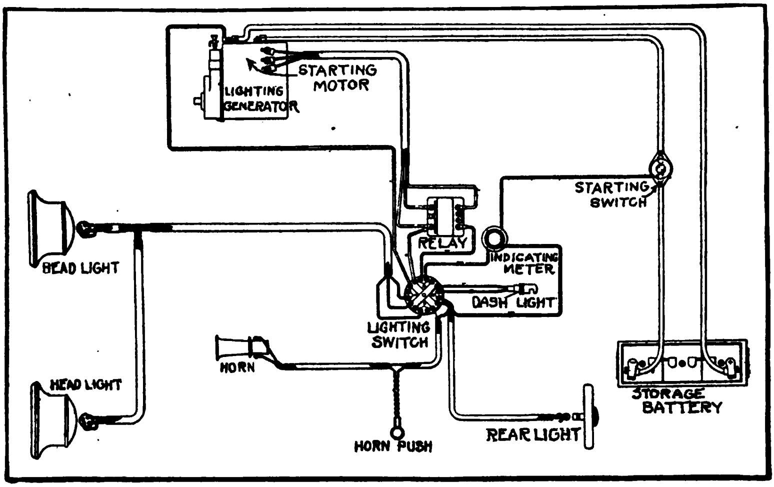


Fig. 244.—Wiring Diagram of Remy-National Two Armature System.

and horns in cases of emergency. A new fuse may readily be made of commercial 10 ampere fuse wire. Six volts, single point Mazda bulbs may be used, but their life will not be as long as $6\frac{1}{2}$ or 7 volt bulbs.

Remy Two-Armature Lighting and Starting System.—The electric starting motor and lighting generator on Series AA National cars is the Remy Model 150 six volt system. The electric machine employs two separate armatures and two separate fields, the motor being superimposed upon the generator, although both are in one steel casting, making a neat, compact unit, familiarly

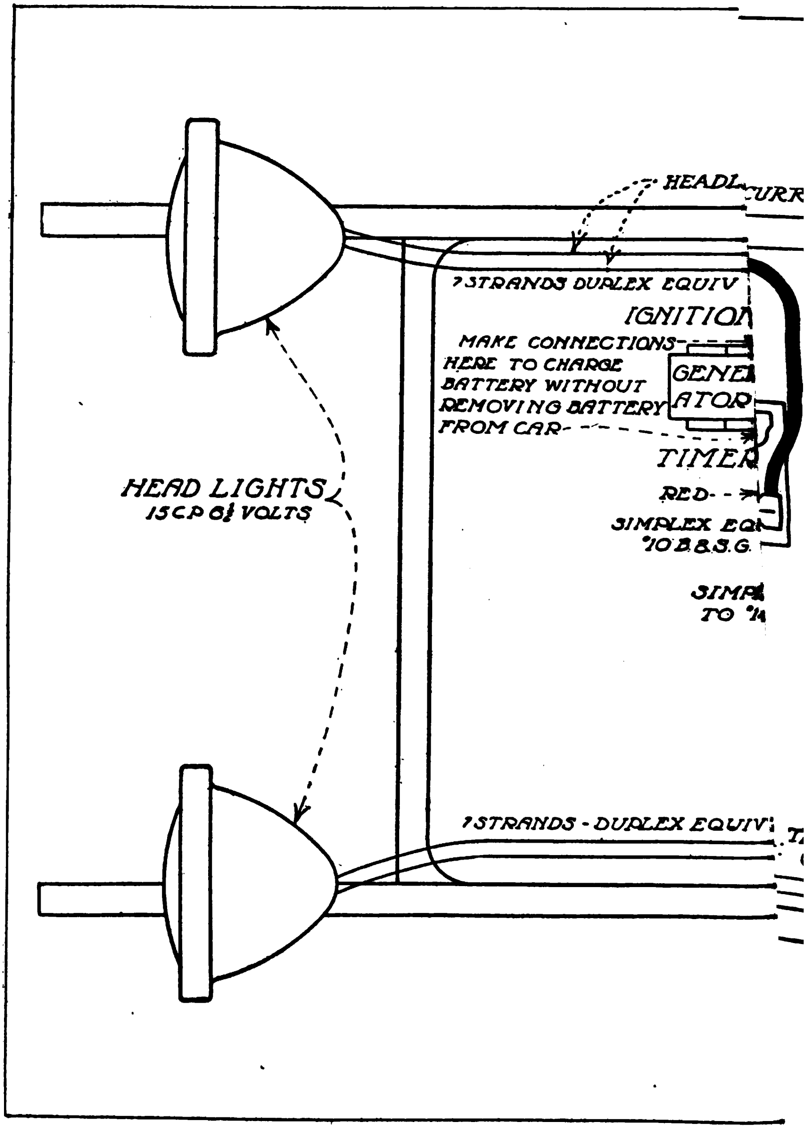


Fig. 243.—Complete Wiring Dia-
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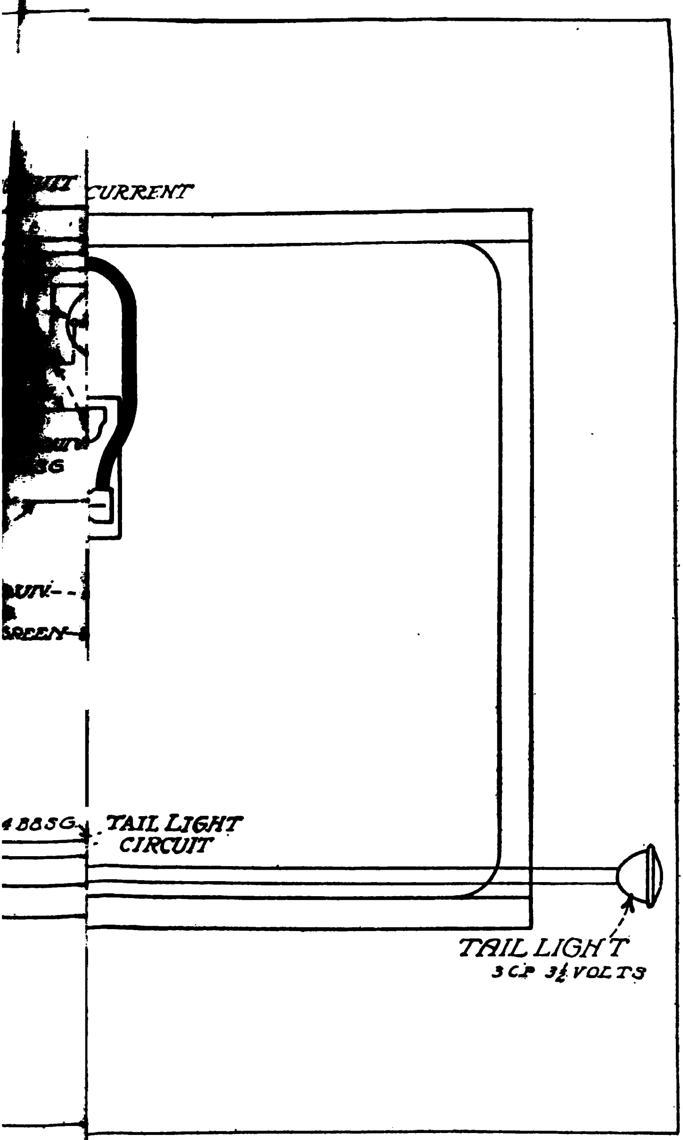

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lubbed a "double decker." The wiring diagram is shown at Fig. 244.

The two armatures are connected together by a train of gears and an overrunning clutch, so that the gears and motor armature are in operation only when the starting switch is pressed. Incorporating the reduction gearing and overrunning clutch of the starting-generator unit in an oil bath, insures silent operation during starting, as external gears and the meshing of the same are entirely eliminated.

The unit has only one drive shaft and is connected to the enine by an Oldham coupling. This allows of quick and easy reioval from the engine for inspection if necessary, although large nspection plates are provided on the unit itself, which is conveniently and accessibly located on the engine. Although the frame for the two units is a steel casting, the magnetic circuits are entirely independent, as may be seen from the illustration. The generator is shunt wound and is automatically regulated for constant current by a vibrator, which is mounted on the same base with the relay or electric cutout. The function of the regulator is to keep the output of the generator constant regardless of the speed of the engine. The relay is simply an electric switch which opens and closes the circuit between the generator and battery automatically to prevent dissipation of battery current in the generator when the engine is at rest.

The motor is of the conventional series type and is wound to withstand heavy overloads. Armatures, brush holders, fields, etc., are built in accordance with standard electrical practice. The generator windings are protected against injury by means of a fuse located on the relay-regulator base. Should the battery become disconnected either through accident or neglect, this fuse will burn, thus protecting generator and field against excessive voltage, which would result if the field circuit were not opened.

To start the engine the operator presses the starting switch, which puts the motor armature into motion, engages the gearing and clutch, and turns the engine over. When the engine is running under its own power the clutch and engine are automatically disengaged and the unit operates only as a generator. The lamp

load of the car is carried by the generator at about 12 miles per hour. As a "tell-tale" an indicator is employed, from which the operator may determine whether the generator is working properly. A simple lighting switch is used for turning on any combination of lamps. No side lamps are used, as the head lamps contain small independent bulbs for signal lamps. The two-wire system of wiring is used. It has been carefully developed, resulting in a very simple layout, as may be seen from the accompanying wiring plan of the system as applied to the six-cylinder National car.

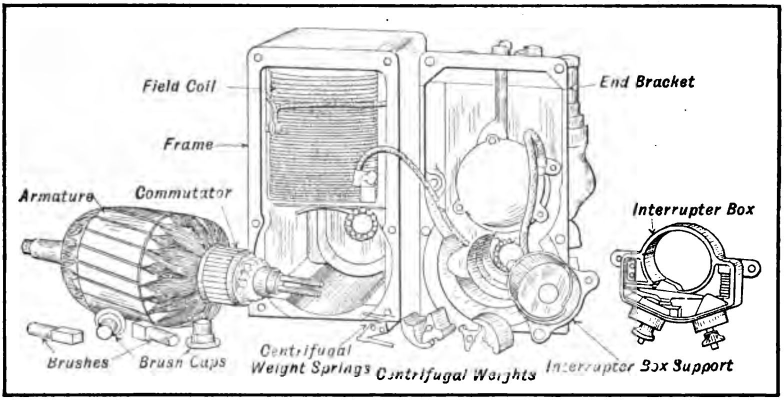

Fig. 245.—View Showing Construction of Westinghouse Ignition Generator.

The Westinghouse Systems.—The Westinghouse systems operate on the regenerative principle, i.e., when the engine is not running or when it is running at a very low speed the current load is taken by the battery and the power thus absorbed is returned to the battery when the car is running at usual speeds during the day. The generator has an output at average car speeds sufficient to carry an ample lighting equipment without drawing on the battery for power. The Westinghouse generators are compact and are intended to operate at the usual magneto shaft speed. They can be connected directly to the driving shaft with an ordinary Oldham coupling, and the design is such that the center line of the armature shaft is at the usual magneto shaft height. When a generator

attains a speed higher than that at which it generates the battery voltage, an automatic switch inside the generator automatically connects the generator to the circuit. This switch is so adjusted that it disconnects the generator at a speed about 25% lower than the "cut in" speed, the difference in speed between "connection" and "disconnection" provides against the switch operating "in" and "out" continuously when the car is running at the speed at which the switch closes the circuit.

As is common in other systems mentioned the generators are of two types with respect to the regulation of output. In one the current supplied by the generator is regulated inherently by the winding of the machine, the control of the voltage depending upon the storage battery. In the other type an automatic potential regulator which forms part of the generator keeps the voltage constant and regulates the battery charge. The Westinghouse generators can be furnished with or without ignition parts. Where the ignition is incorporated with the generator, as at Figs. 245 and 246, the general construction follows closely that of other battery ignition systems in principle as the battery current is transformed in an induction coil to a value sufficiently high to overcome the resistance of the air gap at the spark plugs. The interrupter is mounted on the generator shaft and the contacts are operated by a centrifugal device that automatically times the degree of spark advance to the speed of the engine. The distributor is of the usual face plate type but specially designed so the distributor plate can be placed in position without interfering with the contact brushes and without the use of tools. The internal wiring of the ignition-generator is shown at Fig. 247.

The various forms of Westinghouse generators have been previously described. All the Westinghouse motors are series wound and are entirely enclosed. The rectangular shape is followed in some which makes them easily located and permits the rigid mounting. The motors may have integral planetary reduction gearing or may be provided with shafts to permit of mechanical or automatic shifting of the pinion with the flywheel gear. The starting switches are of two types, the mechanically actuated and the magnetically operated types.

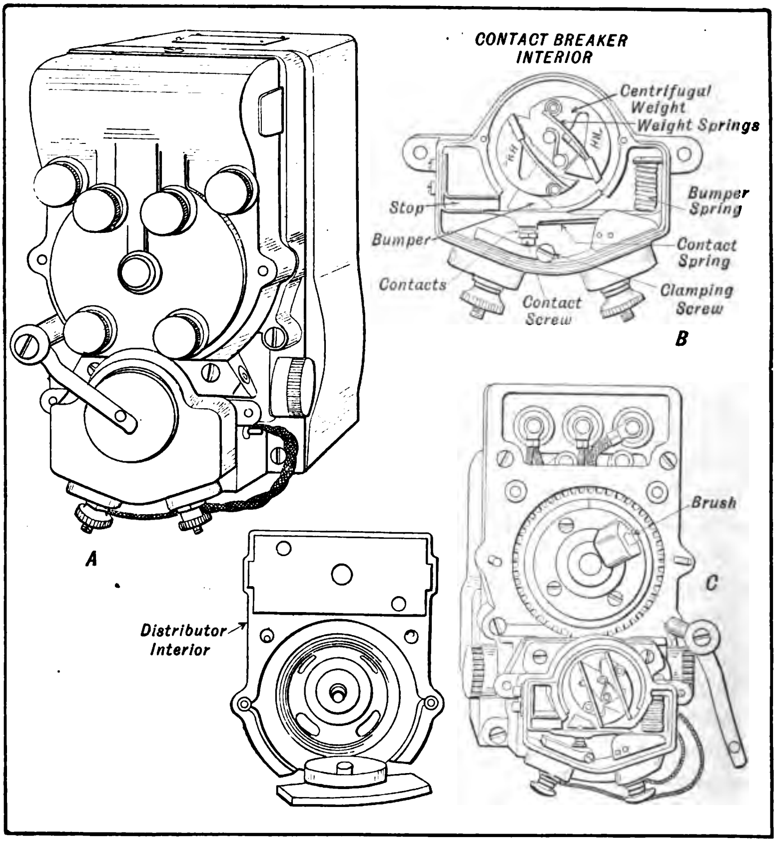

Fig. 246.—Showing Arrangement of Ignition Parts of Westinghouse Ignition Generator Unit.

The Westinghouse starting motor using the automatic gear shift is made in two patterns, as shown at Fig. 248. One of these, known as the inboard, is so mounted that rotation of the armature shaft draws the starting pinion toward the motor. The outboard design illustrated below it is so arranged that the pinion is shifted away from the motor when the armature starts to turn. Obviously, the way the pinion will shift is determined by the angularity of the spiral thread. If the thread is right handed the pinion will be

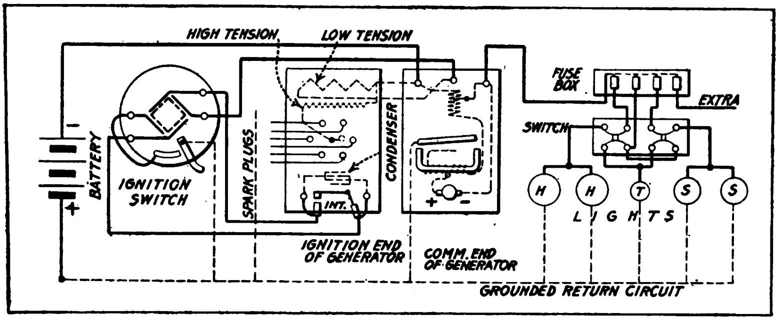

Fig. 247.—Wiring Diagram of Westinghouse Ignition Generator.

shifted in one direction, if left handed it will be moved in the other. The inboard type of motor is intended for use where the flywheel is exposed while the outboard form has been designed for attachment to the flywheel case of a power plant having an enclosed flywheel. The two switches are also shown in this illustra-

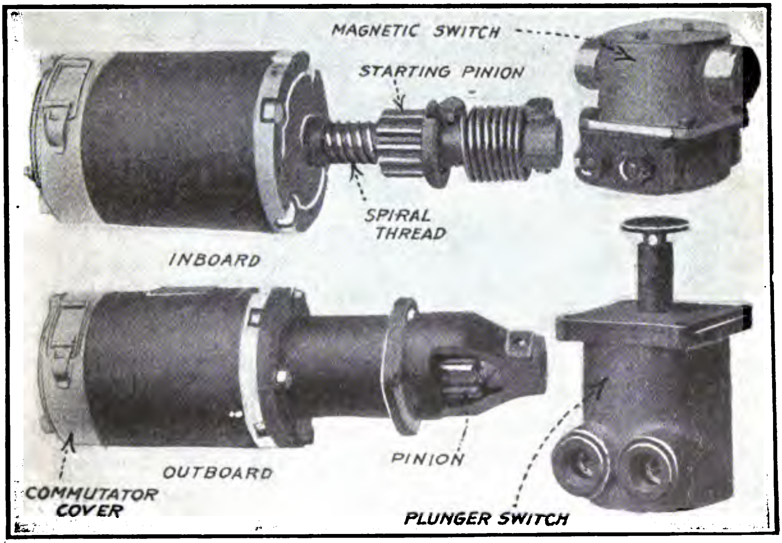

Fig. 248.—Two Types of Westinghouse Starting Motors and Operating Switches.

tion. The magnetic switch is a simple form operated by a push button. The plunger switch follows the conventional design for devices of this character. The wiring diagram when the plunger switch is used is very simple as outlined at A, Fig. 249. The other circuit at B shows the method of connecting the electro-magnetic starting switch.

The application of a Westinghouse generator of the simple form to a 1916 National Twin Six engine is shown at the top of Fig. 250. The method of mounting the starting motor is clearly shown in the top view of the motor at the bottom of the illustration. The

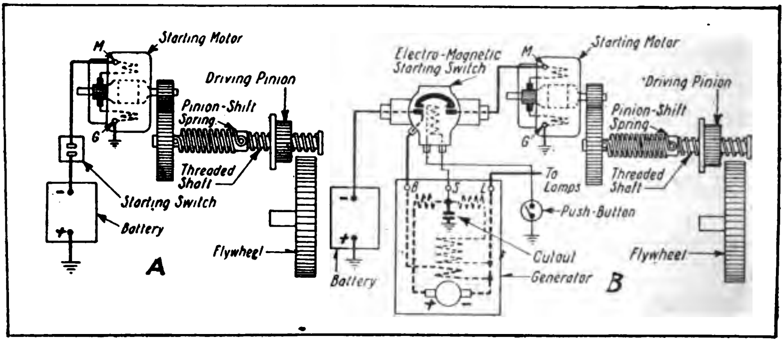

Fig. 249.—Wiring Diagram Showing the Use of the Westinghouse Starting Motor with Mechanical Switch at A and with Magnetic Switch and Generator at B.

wiring of the Westinghouse lighting circuit is shown at Fig. 251. This does not differ greatly from other one wire systems having a separately mounted current regulator. The complete wiring diagram presented at Fig. 252 is that used on the Pierce-Arrow closed cars and shows all necessary connections as well as the various circuits for a comprehensive starting and lighting system.

The various accessory devices comprising the Westinghouse system are built on approved electrical principles. Some of these are shown at Fig. 253. To prevent injury to the battery and lights through short circuits due to accidents or carelessness, fuses should be used in all lighting circuits. The Westinghouse fuse boxes are not only thoroughly enclosed but they are arranged to use enclosed

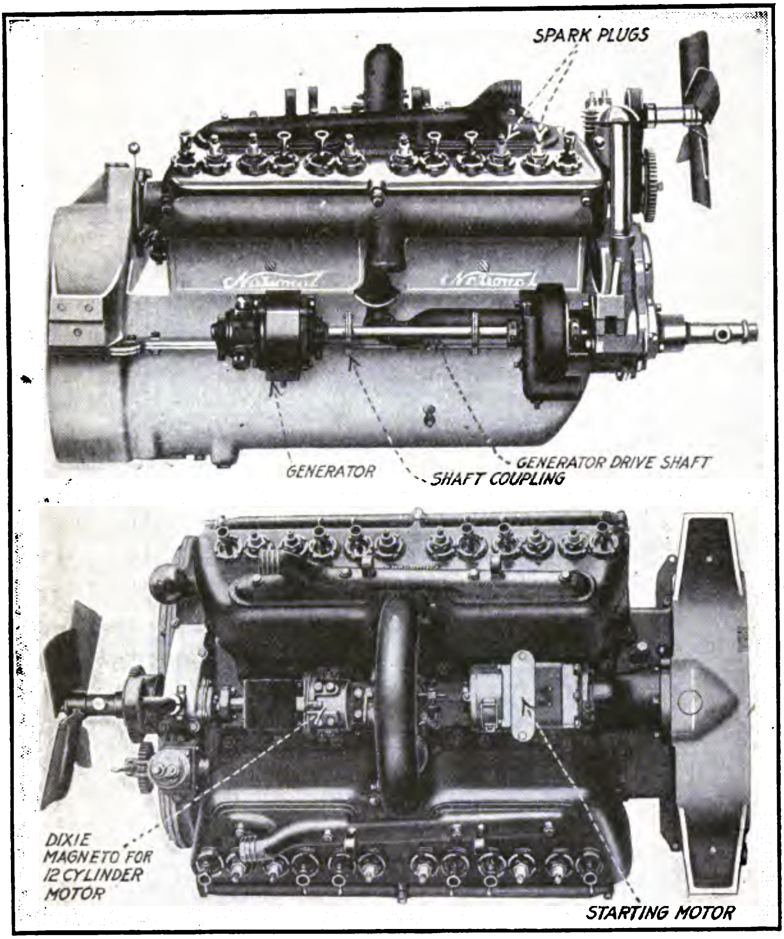

Fig. 250—Views Showing the Practical Application of the Westinghouse Generator and Starting Motor to National Twin Six Engine.

fuses which do not produce a spark when they blow. A four-circuit fuse box, as illustrated, is necessary if a dome light or buzzer is used, though a three-circuit fuse box will be adequate in the ordinary open car lighting system. A circuit is usually provided for the head lights, one for the side lights, and an extra circuit for

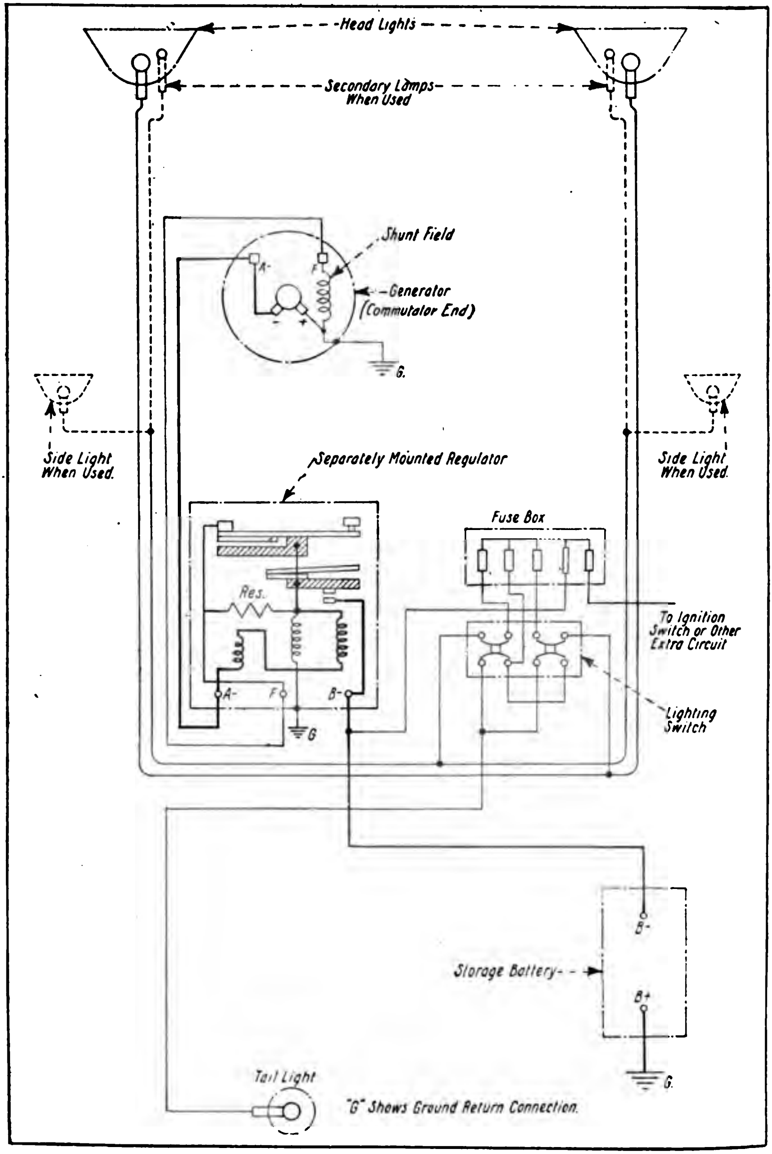

Fig. 251.—Wiring Diagram of Westinghouse Lighting System.

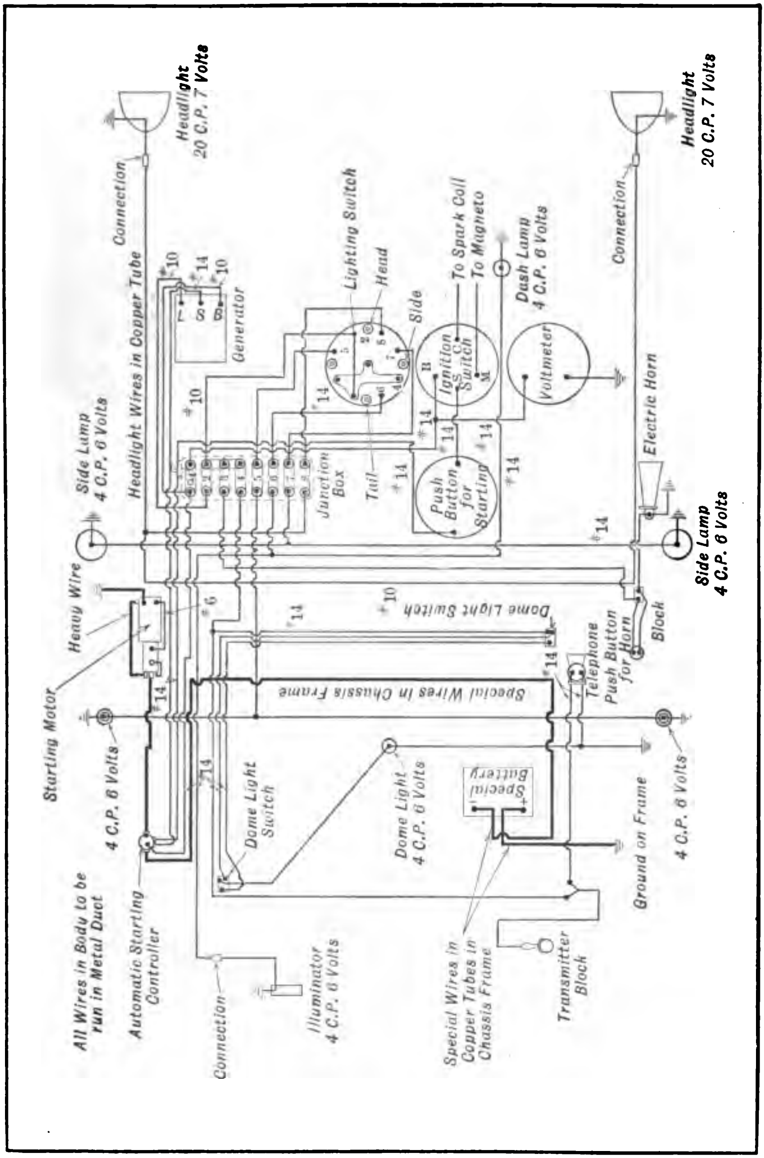

Fig. 252.—Wiring Diagram of Westinghouse Starting and Lighting System Used on Pierce-Arrow Automobiles.

the meter light, horn, trouble lamp, etc. The tail light can be so connected that it will light when either the head lights or side lights are illuminated or when both are used. The screws used for making connections to the fuse terminals are of a pattern that cannot be entirely removed, which prevents their being lost. The fuses

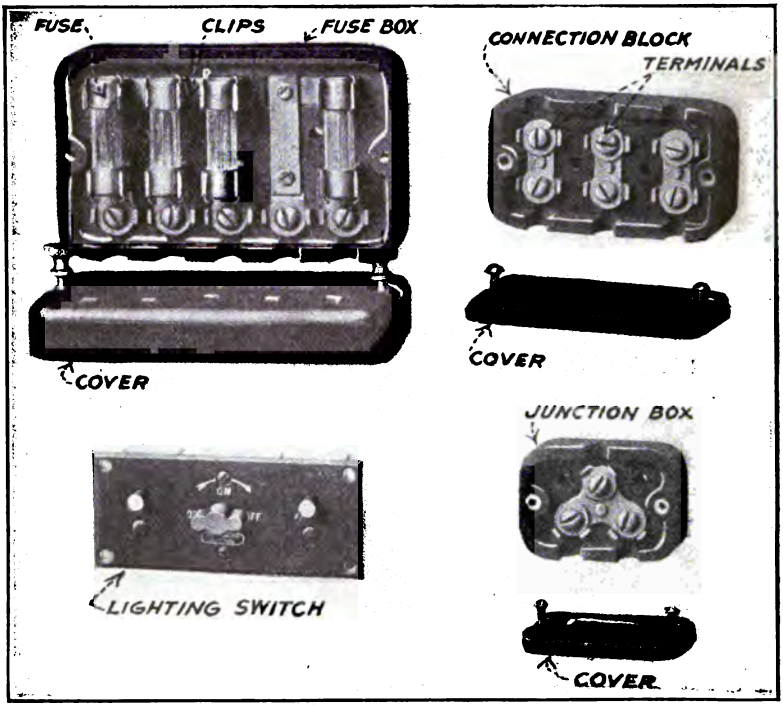

Fig. 253.—Fuse Box, Connection Block, Junction Box and Lighting Switch Used in Connection with Westinghouse Lighting System.

are of the indicating type, or glass tube fuses may be supplied in which the fuse wire itself is visible. A 15 ampere fuse should be used in the head light circuit, a 5 ampere fuse in the side light circuit and 15 ampere fuses in the extra circuit. The lighting switches used are of the push button type and are similar in operation to those used in house lighting. They are made in two, three

and four gang types, or may be of the form shown at Fig. 253, which combines an ignition switch. Coupling boxes are provided to make possible the ready removal of the body from the chassis as these bring all the wiring to one point and make it possible to disconnect the bodies without cutting wires or unsoldering joints. Small junction boxes are used wherever a branch circuit is tapped

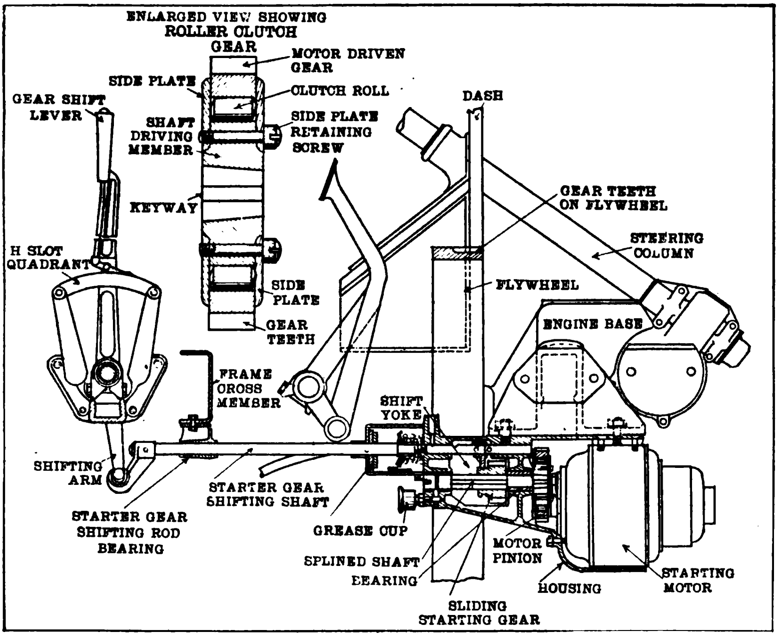

Fig. 254.—Showing Unconventional Starting Pinion Shifting Arrangement Used on FIAT Automobiles.

off the main wiring. These are very useful, as no soldering or taping of joints is required and proper connections are assured.

An ingenious application of a Westinghouse starting motor to the F I A T car is outlined at Fig. 254. The motor is contained in a housing or box attached to the crank case foot and is connected to the flywheel through reduction gearing. A sliding pinion on the electric motor operated shaft is adapted to engage with teeth cut

in the circumference of the flywheel. The motor is started by a switch attached to the rear end of the motor housing, this switch is operated by a lever engaging with a fork attached to the long shaft shown in illustration. This type of control is distinct from others in use as it is operated by the change speed lever, so it is impossible to start the motor when transmission gears are in mesh. The gear shift lever is carried over into an additional slot in the H plate, it of course being impossible to operate the change speed gears as long as the shift lever is in the starting slot. The generator is suspended from a bracket attached to one of the frame cross members and is driven by means of a silent chain from a sprocket attached to a flywheel. The generator supporting bracket is provided with a simple means of adjustment to take care of the chain stretch. The generator mounting is not shown in the illustration.

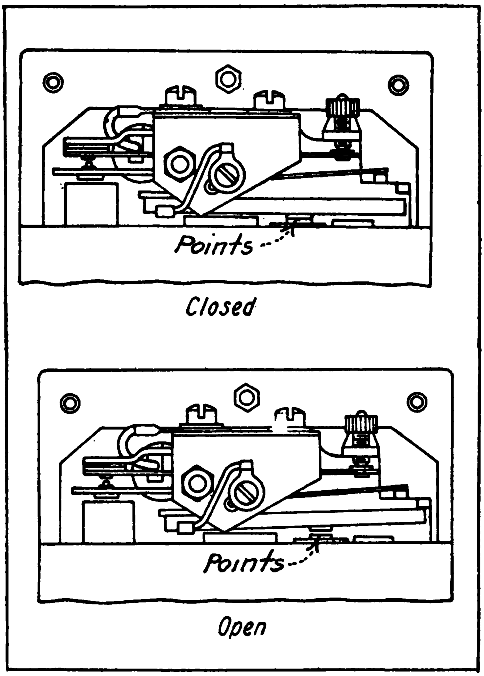

Fig. 255.—View Showing Operation of Westinghouse Automatic Cutout.

The Kemco Fan—Generator System.—Considerable difficulty has been experienced by motorists owning old-model cars and desiring to fit electric-lighting systems on account of no provision having been made by the makers of the car for installing or driving a suitable generator of electricity. A combined fan and dynamo which is novel in construction is shown at Fig. 256, A. In this

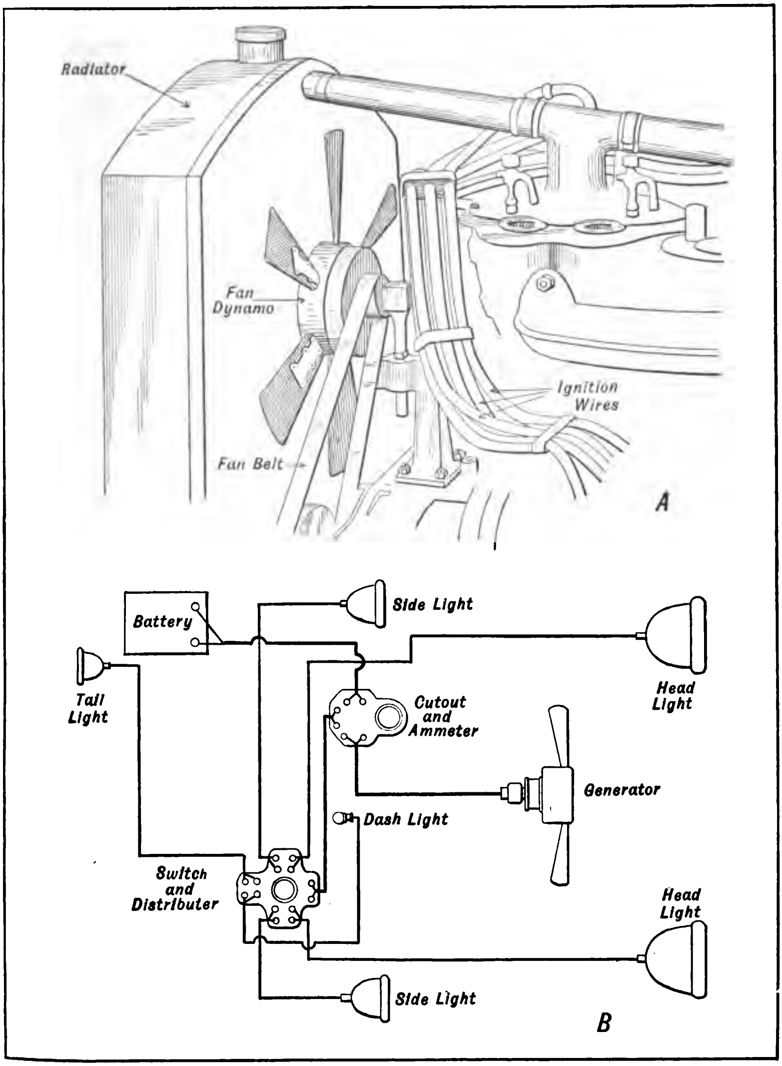

Fig. 256.—Showing Method of Utilizing the Kemco Combined Fan and Dynamo.

the rotary member of the generator is provided with a series of fan blades and is intended to replace the cooling fan usually supplied on most cars, whether air or water cooled. The dynamo portion is very compact and very little of the efficiency of the cooling fan is sacrificed to obtain the advantages incidental to electric lighting. The generator is so arranged that it may be driven by the fan belt in just the same manner as the fan originally supplied

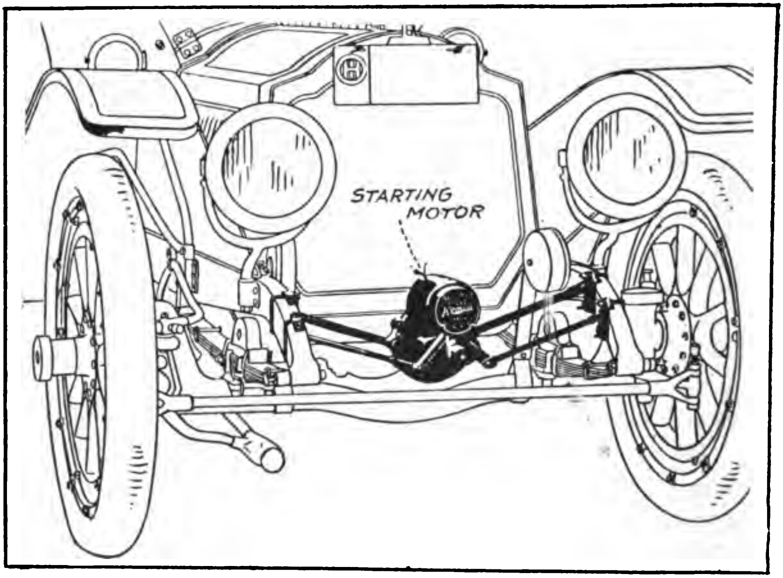

Fig. 257.—Method of Installing the Kemco Starting Motor.

with the car. A wiring diagram showing the method of installing the various components comprising the Kemco lighting system is presented at B, while the appearance and method of mounting the generator are shown in the drawing above it.

The application of the Kemco Starting Motor to a car that was not designed initially for a self-starting system is shown at Fig. 257. This motor takes current from the storage battery in a conventional way, the battery being kept charged by the Kemco Fan-Generator. The application is extremely simple, the motor

being geared down by integral reduction gearing and a suitable clutch provides for its connections to the crankshaft. The starting unit is carried by simple bracket members attached to the spring horns.

The cranking motor is designed to fit on the front of the car, replacing the hand crank, and to duplicate the action of hand cranking. When the switch button is pressed the same starting clutch as would have been employed with a hand crank is slipped into engagement with the crankshaft and the motor is spun until it fires. When the engine starts under its own power the starting clutch is automatically thrown out in the same manner that the hand crank is thrown out of engagement when the engine starts.

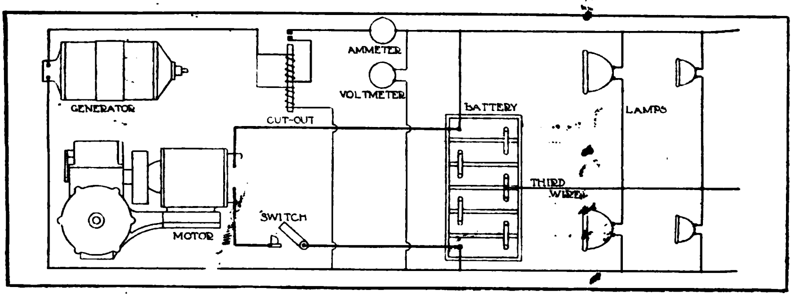

Fig. 258.—The Hartford Starting and Lighting System.

The system works at 6 volts and should be installed in connection with a 100-ampere hour storage battery. The starter is made in two different sizes so that all classes of cars are covered. The gear ratio between the armature of the cranking motor and the crankshaft is 9.5 to 1.

Some of the special electrical features in connection with this machine are particularly its automatic action in engaging to the crankshaft by means of a magnetic control when the starting button is depressed. The release is altogether independent from the solenoid coil which engages the cranking motor with the crankshaft, being due, as explained, to the declutching of the cranking motor. The starter is controlled by the car operator by a button depressed by the foot. It can be applied to practically any make of car by

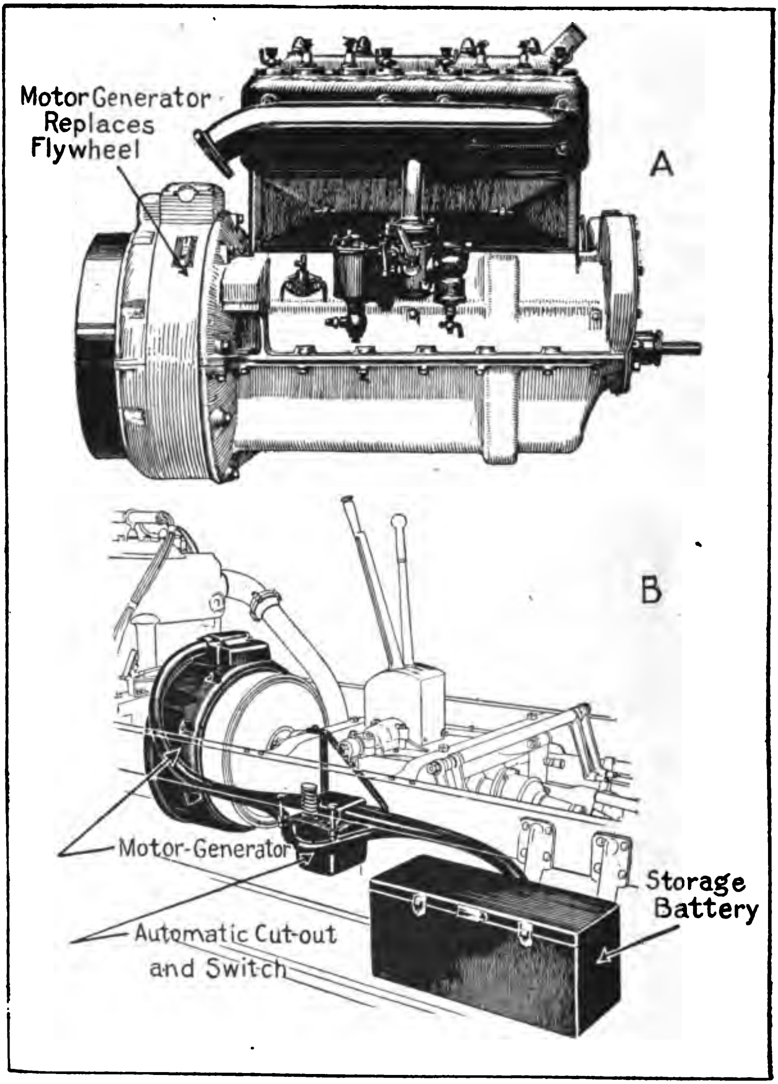

Fig. 259.—U. S. L. One Unit Starting System in Which Combination Motor-Generator Replaces the Engine Flywheel.

means of universal fittings which attach across the front of the frame and are adjustable in every possible way so as to fit the car properly. With this arrangement no drilling or machine work is necessary. In connection with the new cranking motor there is also brought out a positive drive for the Kemco fan generator. This gives an improved two-unit starting and lighting system with which a car can be completely electrically equipped. The overall dimensions of the cranking motor are 9 by 7 inches. Its weight is approximately 3 pounds and since the weight of the generator is 11 pounds, the two principal units total less than 50 pounds.

A special two-unit electric starting and lighting system for Ford cars has also been brought out, operating on the same principle as the larger one but adapted especially for the Ford.

Hartford Starting System.—The wiring diagram at Fig. 258 shows clearly the method of connecting the various appliances forming part of the Hartford starting and lighting system. This is a 12 volt, two wire starting system, with a connection so the lamps receive their current from the battery on the three wire system. The two terminals of the generator are connected to the storage battery in the usual way, one directly to a terminal, the other through the automatic cutout. When the knife-switch is closed, the battery current flows through the motor windings and turns the engine crankshaft. The connections are so clearly shown that further description is unnecessary. The speed of the generator armature is governed by the centrifugal governor, which is designed to keep it at 1200 revolutions per minute. The lighting switch is of the selective barrel type, having three positions of the handle, one of which will give the head and rear lamps, the intermediate position lighting the side and rear, while the last position sends the current through all the lamps. This switch is not shown in the diagram.

U. S. L.-Jeffery System.—The complete starting system shown at B, Fig. 259 used on 1913 and 1914 Jeffery cars, is one in which the motor-generator replaces the gasoline engine flywheel. This means that it is directly connected to the motor crankshaft and does not employ any reduction gearing of any form. The various members comprising the starting system are indicated in heavy

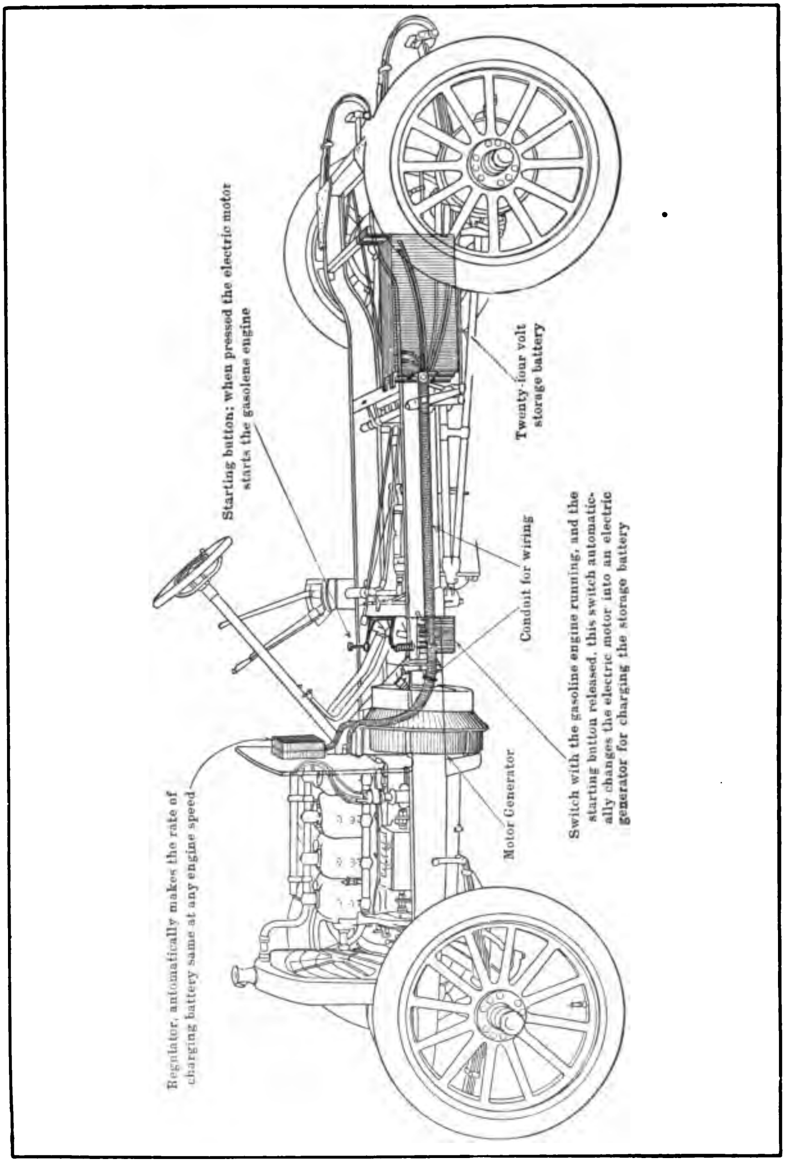

Fig. 260.—View of Complete Automobile Chassis Showing the Application of U. S. L. One Unit Starting and Lighting System, in Which the Motor-Generator Forms Part of the Power Plant Flywheel.

black lines, while the rest of the chassis is shown in light black lines. The system is simple and easily understood. An automatic switch which changes the electric machine into a generator for charging the storage battery when the gasoline engine is running and the starting button is in its released position is one of the important parts. The regulator which makes the rate of charging the battery the same at all engine speeds is placed on the dash. The simple operation of depressing the starting button when the gasoline engine is not turning changes the flywheel generator into an electric motor that draws current from the twenty-four volt storage battery and which rotates the motor crankshaft. A Jeffery motor, with unit motor-generator replacing the flywheel, is shown at A, Fig. 259, while the complete system in its relation to the other parts of the motor car chassis are shown at Fig. 260.

CHAPTER VI

STARTING SYSTEM FAULTS AND THEIR SYSTEMATIC LOCATION

Indications of Trouble in Gray & Davis Systems—Faults in Motors and Generators—Commutator Faults—Fitting Brushes—Faults in Wiring—Care of Lamps and Storage Battery—Delco System Troubles—Testing for Defective Windings—Defects in Dyneto Systems—Troubles in Bosch-Rushmore System—Remy System Faults.

THIS portion of the treatise is intended primarily for the mechanic who may be confronted with more or less complex problems in caring for and repairing the electrical system, though the instructions given are sufficiently complete and so simply expressed that the motorist can avail himself of them. The mechanic who has had experience on electrical apparatus has invented methods whereby he checks or tests various parts of the apparatus, but quite often these checks or tests are not infallible. It is the aim of this chapter to point out to the mechanic the most practical manner of making reliable tests. The importance of searching for trouble in a systematic manner cannot be too strongly emphasized. The expert always follows a definite course of procedure in locating derangements, the amateur works in a haphazard manner and seldom accomplishes anything. One finds trouble by a process of search and elimination, the other finds it by good fortune if the fates are kind.

Locating Troubles in Gray & Davis System.—In event of trouble with the Gray & Davis lighting system, the makers recommend a careful study of the symptoms, which will usually provide a guide to find the component at fault. The indicator on the dash shows positively any failure of the generator or any break in the wiring. If the indicator does not indicate "charge" when the engine is speeded up but shows "discharge" when lights are turned on and the engine at rest, the dynamo or current regulator is not

working properly. A common trouble is the dynamo brushes not sliding freely in their holders. If the dynamo is driven by friction belt this may be too loose to drive the dynamo at proper speed. If the indicator does not indicate "charge" with the engine speeded up and does not indicate "discharge" with the lights on and the engine at rest, one should look for an open circuit or loose connection in the battery wiring or for corrosion or looseness in the

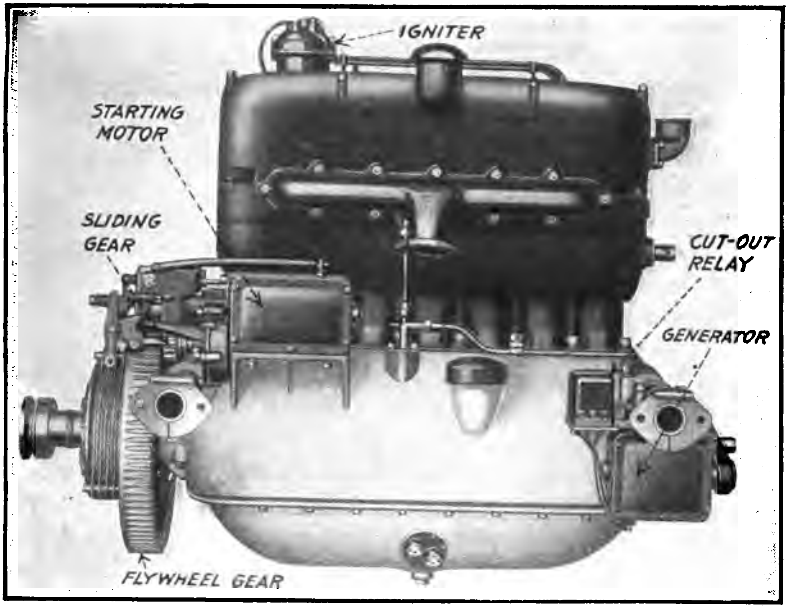

Fig. 261.—Chalmers Engine Showing Location of Gray & Davis Starting Motor, Generator and Cutout Relay.

storage battery terminals. Sometimes the dynamo terminals may have loosened and imperfect contact exist at this point. Should the indicator show "discharge" with the lights turned off and engine at rest (providing that the indicator pointer is not bent), the insulation on lamp wires may be injured, this permitting contact with the frame, causing a short circuit. If the indicator indicates "charge" with the engine at rest, it is a positive indication that the pointer is bent.

If the charge indications are below normal with the engine running, it may be on account of slipping of the driving belt if the dynamo is driven in that manner, or because of poor adjustment of the centrifugal governor, if that type of dynamo is used. If the ammeter "discharge" indications are above normal it is a sign that the lamp load is excessive or one of the lamp wires is in contact with the frame. When the indicator pointer jerks from one reading to another with engine running at constant speed on the discharge scale, it means either a short circuit in the system or a loose terminal. If trouble is experienced from fuses burning out repeatedly, it is a sign that the lamp wires are in contact with the frame at some point or that one of the lamps is defective because of a short circuited filament. If the engine cranking speed is very low and this is not due to the engine being stiff, such as would be the case in cold weather or after the engine has been overhauled and bearings tightened, it may be considered a positive indication that the storage battery is almost discharged or that it is defective in some way. If the starting motor does not rotate; the battery may be discharged, the starting switch may not be making good contact or a motor brush may not make good contact with the commutator. There may be an open circuit in the battery wiring to the motor, or there may be a poor circuit or contact because of corroded battery terminals. If the starting motor rotates but does not crank the engine, it is a sign that the overrunning clutch does not work properly or that the starter pinion is not properly meshed with the flywheel gear.

If the lamps will not light but the starter cranks the engine, this shows that the storage battery is in proper condition and that the trouble is due to burned out or broken lamp filament or defective lamp fuses. If the lamps burn brightly but fail to illuminate the road sufficiently, the bulbs may be out of focus in respect to the parabolic reflector of the lamp or the lamp supports may be bent in such a way that the rays of light may be directed too far upwards. If the lamps burn dimly or not at all and it is difficult to crank the engine with the starting motor, this means a weak or discharged storage battery. In addition to this, the lamps may be old and have blackened insides, the system might be slightly short

circuited, or considerable resistance may be present, due to loose or dirty connections. If the lamps blacken or burn out quickly they are not of the proper quality if they are six volt lamps, and not of the proper voltage if other than six volt lamps. There is one exception to this rule, and that is the bulbs of the tail lamp and dash light, which are three volt lamps when these two are wired together in series. Burning out of the lamps may be caused by the regulator not working properly, and if this is the case the lamps will burn out at high engine speed. If the lamps flicker and the ammeter or indicator needle is unsteady, look for loose connections in the light wires, loose connections between battery and dynamo, loose contact at a lamp connector or lamp bulb, poor contact between fuses and fuse clips, or an exposed wire touching the frame intermittently.

If one suspects that the battery is discharged, its condition may be readily determined by using the test lamp, shown at C, Fig. 201. The test lamp may also be used for locating short circuits or open circuits. It is well to bear in mind that the lead terminals of the battery should be scraped clean and bright at the point where the test lamp wires bear in order to insure a good clean contact. If the test lamp burns brightly it shows that there is current in the storage battery. To locate a short circuit the fuses are removed from the rear of the switch and the wire is disconnected from the negative battery terminal. Connect one of the test lamp terminals to the free battery terminal and touch the other test lamp wire to the frame of the car. The test lamp should light if good contact is made, this indicating that the positive battery terminal is properly connected to the ground. Keep one test lamp wire in contact with the negative terminal and touch the other wire to the end of the battery wire just disconnected. If the test lamp lights it shows that a conductor or wire connected to the battery, lamps, horn or starting motor is in contact with or grounded to the frame of the car.

Any wires having injured insulation should be wrapped with electrical tape to prevent metallic contact between the conductor and the frame. Open circuits are best indicated by feeling of the wires where they fasten to the terminals to make sure that posi-

tive contact is made and that the terminal binding nuts are not loose. Short circuits may also be located if no test lamp is available by following the various wires, and if any of these are found in contact with the frame it is a wise precaution to pull them away and to wrap the section that was in contact with the frame thoroughly with insulating tape. If one lamp flickers and the rest burn brightly, look for a poor connection between the lamp and the lamp connector, a loose terminal at the junction switch or a defective fuse. If all lamps flicker, look for loose connections in wiring between battery and junction switch. When lamp bulbs have been renewed in head lights it is sometimes necessary to refocus the lamps. Head lights should not exceed 15 candle power, and should always be of the high efficiency filament type. Cheap carbon filament lamps will not only consume undue current but will not prove enduring. Tungsten filament lamps are best.

Faults in Motors and Generators.—While every effort has been made by the manufacturers of electric starting and lighting systems to have the various units function as nearly automatically as possible, it will be evident that some attention will be needed by the various units. The generator should be looked over from time to time and should any carbon dust be worn from the brushes by the commutator and deposited in the lower part of the casing it should be blown out with compressed air. It is stated that an accumulation of this dust may result in a ground to the generator case or produce a short circuit between the brush carrier and case. If the commutator is blackened or rough it must be smoothed down with fine sandpaper while the armature is rotating. Never use emery cloth for this purpose. After smoothing down the commutator remove all particles of metal which may bridge across between the copper segments. The insulating material between the commutator segments should not be higher than the surfaces of the segment, and if any of it projects it must be filed down slightly lower than the copper pieces by using a small file as shown at Fig. 264.

The brushes are the part of the generator that demand the most attention and to which most of the troubles in devices of this kind are due. They should be examined to see that they are in perfect

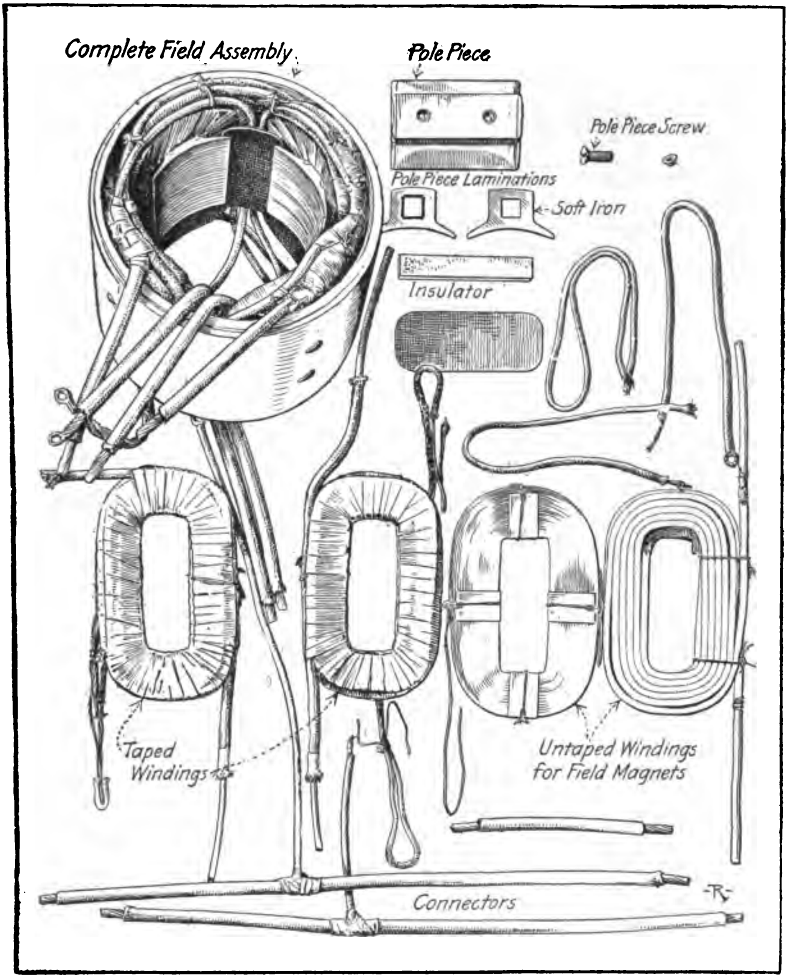

Fig. 262.—Parts of North East Motor-Generator Field Assembly.

contact with the commutator and that they do not stick in the brush holders. Any dirt or grease on the brush assembly should be removed. One of the most fertile causes of poor brush contact with the commutator is on account of insufficient spring tension. When examining the brushes care should be taken to see that these

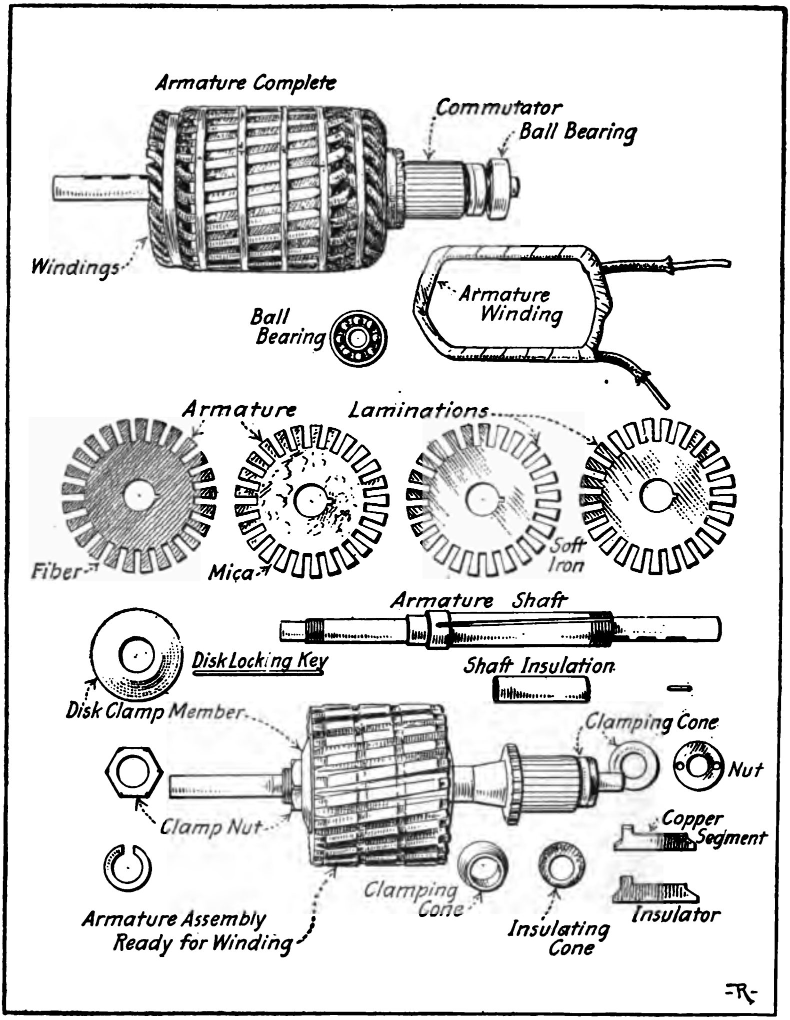

Fig. 263.—Components of North East Motor-Generator Armature Assembly.

are maintained positively in contact with the copper segments. Care should be taken not to have the spring pressure too great, as this would produce rapid depreciation of the brushes and heating

of the commutator. Brushes that have worn down till they are short must be replaced with new ones. When replacing brushes be sure that they fit the commutator surface exactly over the whole area of the end of the brush, and in all cases use brushes for replacement furnished by the maker of the generator. In some generators, shunt connections, which are called "pigtails," are used for connecting the brushes. If the new brushes furnished by the fac-

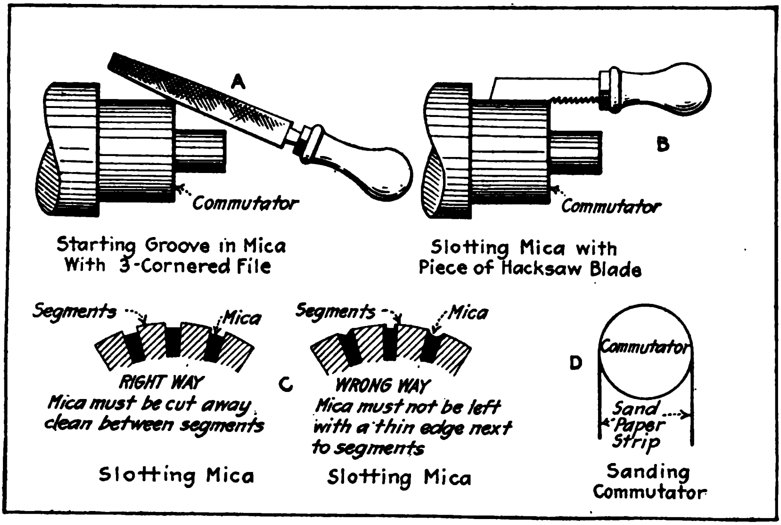

Fig. 264.—Methods of Grooving Insulation Between Commutator Segments at A and B and Right and Wrong Way of Slotting the Mica at C. Proper Method of Sanding Commutator Outlined at D.

tory have these connections attached care should be taken to make the connection exactly the same as on the old brushes.

It is imperative that the commutator be kept clean, as any oil or grease on the segments will collect carbon dust and produce short circuiting. The brush holders should be entirely insulated from the carrying case, and if any of the insulating bushings, washers or plates are found defective they must be replaced with new ones. Should the battery or generator be disconnected for any reason, do not operate engine again until they are connected. Never run

a generator unless connected to the battery. With the engine running and lamps burning, if the amperemeter hand stays at zero it indicates that the generator is producing exactly the same amount of current as the lamps are consuming. If the hand is on the discharge side of zero it means that the current-consuming units are burning more than the generator is producing. If the pointer is on

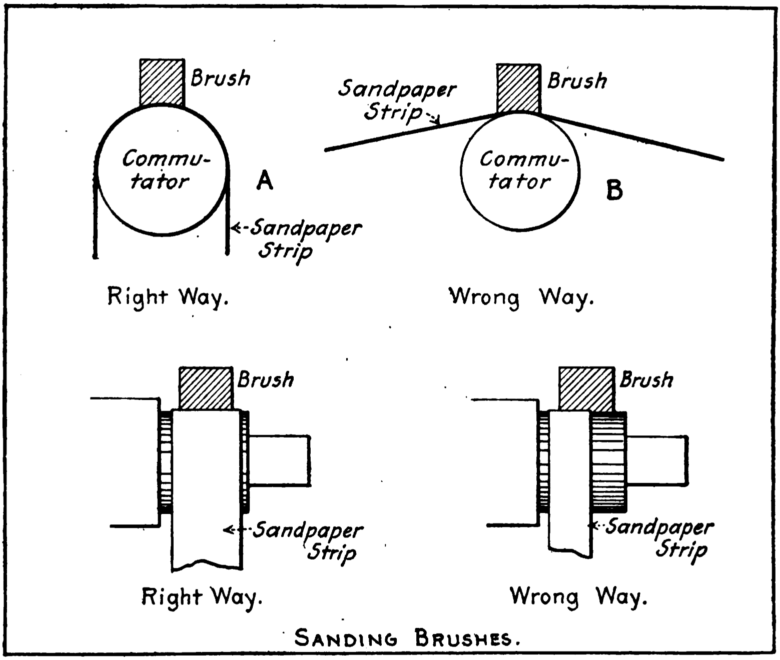

Fig. 265.—Illustration Showing Right and Wrong Way of Sandpapering Brushes.

the charging side of the scale it shows that the generator is producing more current than is being used by the lamps.

The starting motor is subject to the same electrical troubles as the generator is. These are grounds, short circuits, brush and commutator troubles. Defects in either the motor or generator drive are of a purely mechanical nature and can be easily located by any competent repairman. The centrifugal governor used on many

generators is not apt to give any trouble unless some of the parts fail or the action becomes clogged with oil and grease. If the springs tending to return the weights are broken or become weakened the generator will not deliver the proper amount of current because the drive will not be positive. Any accumulation of oil that will interfere with proper frictional adhesion between the clutch parts where a governor is employed will also result in failure to drive.

Faults in Wiring.—In the two wire system every wire, connector and socket must be insulated from the car and should not be in metallic contact at any point except at the terminal. It is imperative that all wires be insulated from each other and the car frame except at points where permanent connections are made. All connections should be soldered to insure positive contact and securely wrapped with insulating tape. The wires must be held securely by means of cleats of insulating material and must be mounted in such a way that there is no possibility of sharp metal corners or edges wearing through the insulation and causing grounds or short circuits.

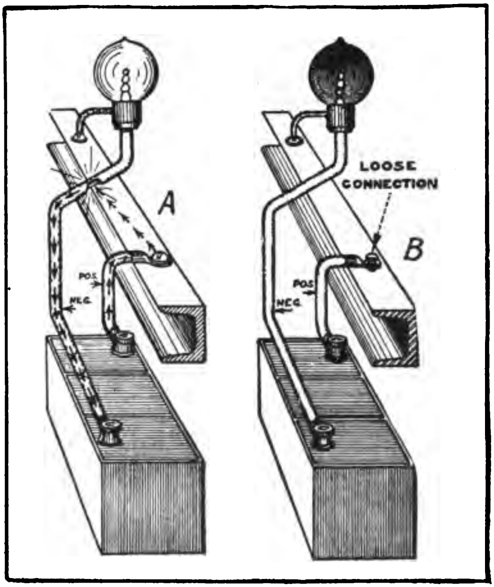

Fig. 266.—Diagrams Defining Difference Between Short Circuit at A and Open Circuit at B.

All wiring should be protected from the rotting action of grease, oil and water, and when the wiring is run where these substances are apt to accumulate, the regular insulation should be supplemented by a conduit of insulating material such as circular loom or

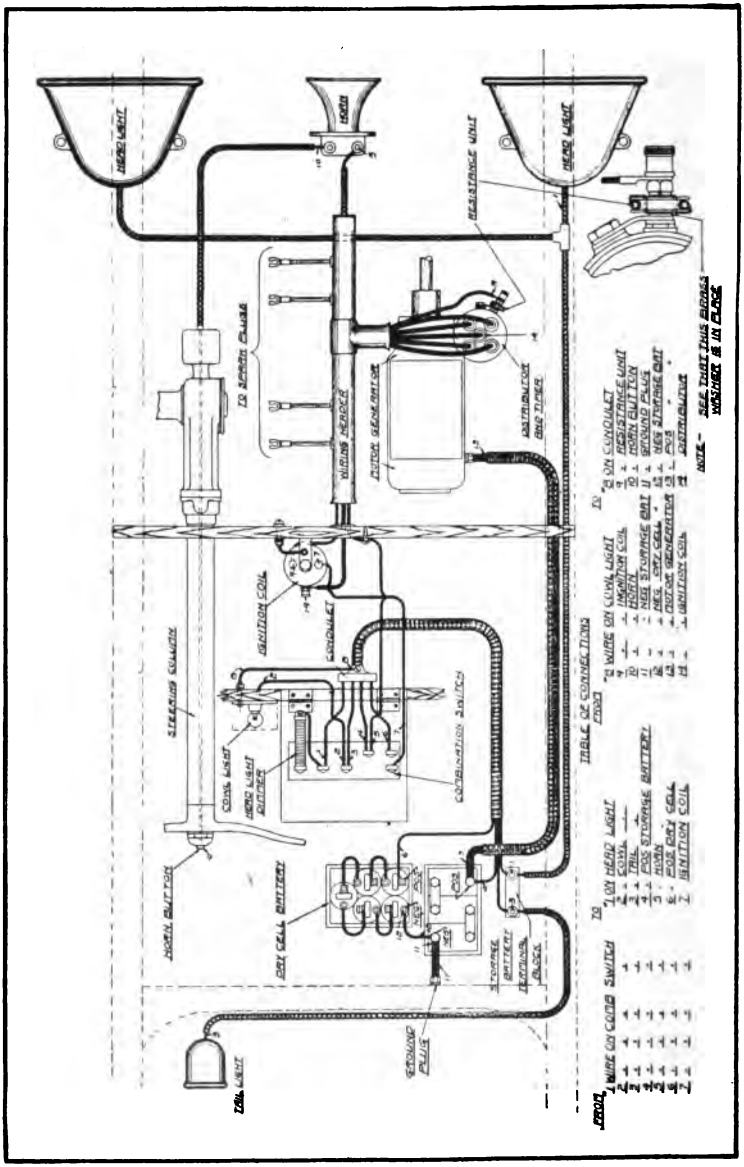

Fig. 267.—Non-Technical Wiring Diagram of Delco-Olds Starting, Lighting and Ignition System.

fiber tubing, or armored cable should be used. All wires should be so installed that there is no danger of interference between them and operating rods and levers. The abrasion of these members will wear through the insulation, and result in short circuits. Brass or copper terminal connections should be used at all points and no connection should be made by winding the strands of wire around the terminal. One or more of the strands may bridge across the terminal or to some metal part and cause a short circuit or ground. Special care should be taken with the connections in the lamps and other points. By the term "short circuit" electricians mean that two wires of opposite polarity are in metallic contact. Under such conditions the storage battery will be discharging and there will be no lights at the lamps. A short circuit may occur at any point in the wiring system, but is usually found at terminals that have been carelessly made or by worn insulation on wires.

The connections in electric wiring should be soldered. The unsoldered connection may work as good as a soldered connection at the time of being made, but the resistance always increases. Do not use acid when soldering electrical apparatus or wiring as the acid is an electrical conductor and destroys insulation. It is much better to use a non-corrosive soldering paste. Do not use friction tape on high tension wiring or on other wiring where the grease or oil can get to it. It is much better to use linen tape and shellac. Friction tape will not insulate ignition current and will not hold when oily.

A short circuit (Fig. 266, A) will be indicated by the position of the amperemeter pointer. Always note the position of the index hand of that instrument when the car is stopped. With the engine at a standstill and no lamps burning the hand should point to zero. If it does not the amperemeter is either out of calibration or there is a leak of current from the battery at some point in the wiring. To ascertain if the amperemeter is correct, uncouple one of the battery terminals of the lighting system. Obviously, if the hand swings to zero, the trouble is leakage of current, which should be immediately corrected after the trouble is located. If the index does not point to zero when the battery terminal is disconnected, the instrument is out of calibration, and while this does not affect the operation of

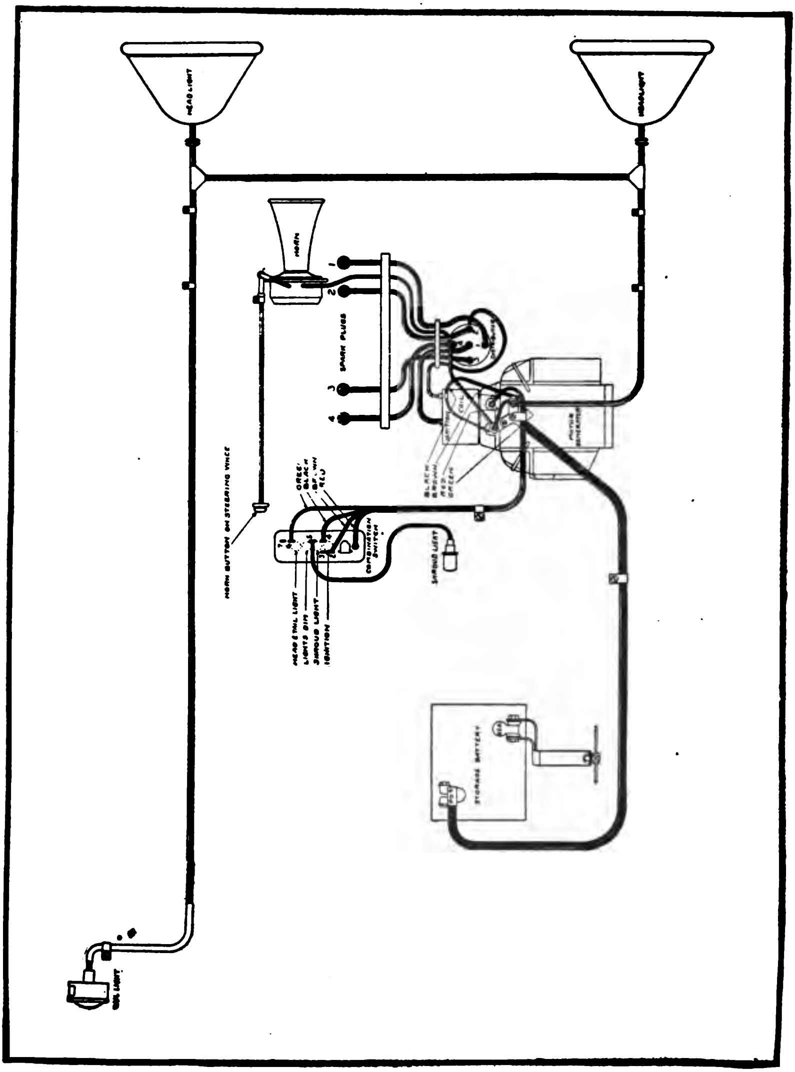

Fig. 268.—Delco Starting, Lighting and Ignition System Used on 1916 Four Cylinder Oakland Automobiles.

the system it should be taken into account when reading the amperemeter. If the engine backfires when the ignition is interrupted and it makes one or two revolutions in the reverse direction, the amperemeter pointer may be found at the extreme of the scale on the discharge side. This is caused by the circuit breaker contact being held closed and means a short circuit of the battery through the generator winding. This must be corrected at once by momentarily disconnecting one of the generator wires or starting the engine. If the wires are removed from the generator for any reason make sure that they are connected to the same terminals as they were originally. If the wires are reversed the amperemeter will indicate a dead short circuit by swinging to the extreme on the discharge side of the scale when the engine is started, and if this defective condition is not corrected the battery will be soon discharged. In case of a short circuit examine all of the wires connected to the battery terminals and to the lighting switch. Make sure that the insulation is perfect and that it has not been cut through at any point. Whenever any wires are removed from any of the units always mark the terminals and the wire so that they will be replaced exactly as they were originally. If a short circuit exists when all the switches are opened, if one takes off a battery terminal and makes and breaks contact between the wire and that member a small spark will be in evidence. If no sparking occurs, connect up the terminal to the battery and then with the engine at a standstill close the switches to the lighting circuit one at a time and watch the amperemeter closely as each switch makes contact. If the pointer does not move far from zero it shows that the current consumption is normal; if, however, the pointer swings to the extreme of the discharge scale it is evident that a short circuit exists somewhere in the circuit just brought into action. All the circuits can be tried in this manner one at a time. If the amperemeter indicates only a normal amount of current consumption for the various lighting circuits it is apparent that no further search is necessary. If, however, the needle indicates a short circuit on one or more of the switch positions, examine the wires carefully for the circuits at fault, and if the trouble does not exist there it may be located in the lamp socket, the connector or the bulb itself.

In case one or more lamps fail to burn the trouble is due to either a broken wire or a defective connection at the switch, connectors or lamp sockets or a bulb or fuse is burnt out.

Care of Lamps and Storage Battery.—The following instructions relative to the care of the lamps and storage battery of the Auto-Lite system are taken from an instruction book prepared by this company and apply to similar components of all systems. Complete directions for the care and charging of storage batteries are given in the preceding chapter, but at the same time a review of the important points to keep in mind in connection with the maintenance of the batteries used in lighting and starting systems will prove of value to the motorist or repairman who does not desire to go thoroughly into the subject of storage battery charging or maintenance.

To clean head and side lamp reflectors, remove from lamp body and carefully blow out any dust which may have collected on the reflecting surfaces. Then dip a small piece of absorbent cotton in alcohol and lightly wipe over the surface—always from the back to the front. To focus the lamps, open the swinging front of the lamp and direct the light upon some smooth vertical surface at a distance of about ten feet. Loosen the adjusting screw on the slide at the rear of the reflector, and move the bulb and socket out and in until all rings disappear in the illuminated area. Then tighten down the adjusting screw and close the lamp. Any further adjustment of the lamp must be made by bending the arms of the lamp bracket with a heavy wrench until the light from each lamp strikes the road at the point desired.

Do not connect additional apparatus, such as electrical horns, cigar lighters, etc., to the system without taking the matter up with the factory. The surplus capacity of the system is large, but there is a limit to the amount of current which the generator can produce. Use the same judgment and reason in the operation of the electric lights on a car as you do those in your home or garage. When a car is running it is not necessary to burn all the lights, the two heads and the tail are all that are required or that are of any service. When the car is standing at night, use the side and tail lights only. When push type connectors are used, if halves of con-

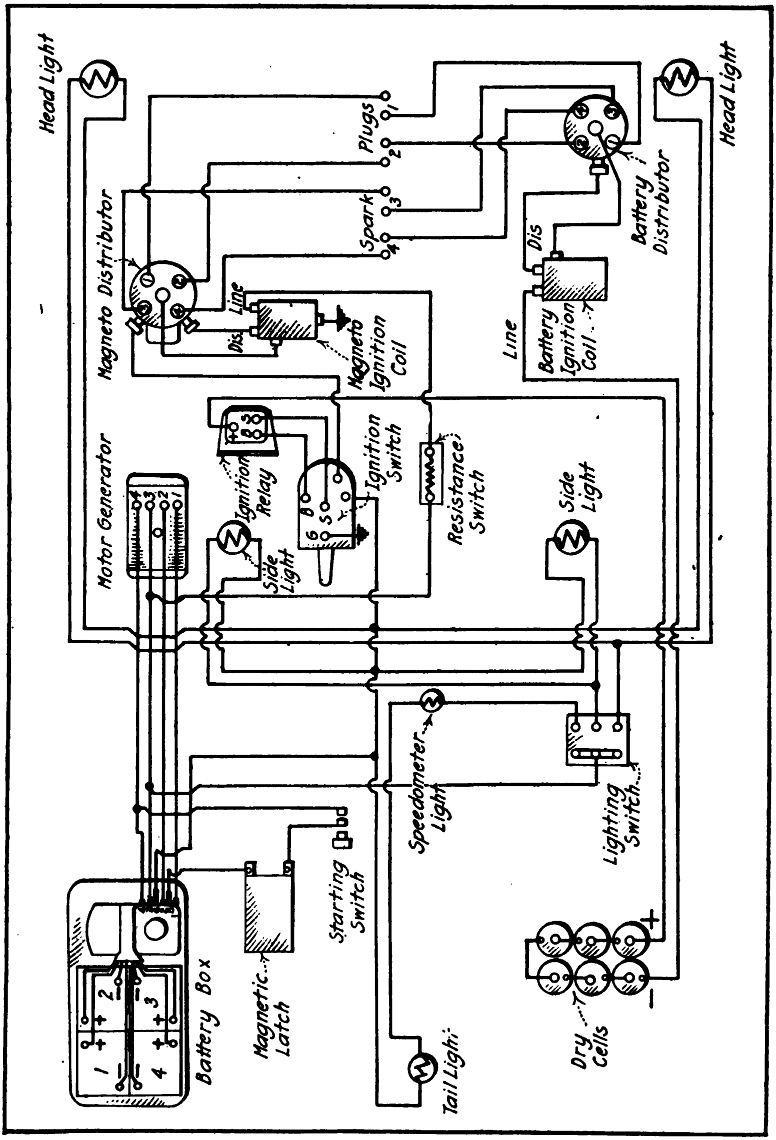

Fig. 268A.—The Delco Starting, Lighting and Ignition System Used on the 1912 Cadillac Four Cylinder Car, the Pioneer of All Starting and Lighting Groups of this Nature.

nectors are loose when pushed together, the contact will be poor. Spread the connector posts slightly so that they will slide in their sockets snugly. If Ediswan type are used, and plunger springs in connector do not operate, replace the connector with a perfect one.

The storage battery is made up of several hard rubber cells or containers for the active plates and liquid electrolyte. The whole is surrounded by a wood casing for mechanical protection and ease in handling. Each individual cell is provided with a screw cap for inspection and the addition of electrolyte or distilled water when necessary (See Fig. 73 and Fig. 74). The electrolyte must at all times cover the tops of the plates at least one-quarter inch. Insufficient electrolyte will result in warped or buckled plates, and an accumulation of sediment at the bottom of the cells. The battery will be ruined in a short time if the tops of the plates are not kept covered. Each cell must be inspected at least once every week in summer and once every two weeks in winter. All screw caps must be removed and distilled water added to each cell to make up for the natural evaporation. If distilled water cannot be had use clean rain water which has not come in contact with metal or cement.

Never add acid to the cells of the battery. If part or all of the electrolyte has been lost through accidental spilling or leakage get full instructions and advice from the maker. An hydrometer, arranged with a rubber bulb to draw a portion of the electrolyte from each cell, furnishes the best indication of the condition of the battery. The hydrometer shows the specific gravity of the electrolyte, which for a fully charged cell should be 1280 on a specific gravity scale. If the car is out of service for a considerable length of time, as when laid up for the winter, it is necessary to charge the battery at regular intervals. This may be done by running the engine at a car speed of twenty miles per hour for at least one hour every two weeks. If the car is to be stored, and it is not convenient to charge as above, the battery should be removed from the car and placed in a reliable garage to be properly taken care of.

If your battery is arranged with terminal posts for the wiring connections these must be examined occasionally to see that they are clean and free from sulphate. The thorough application of a small amount of vaseline at the metal connections to the battery

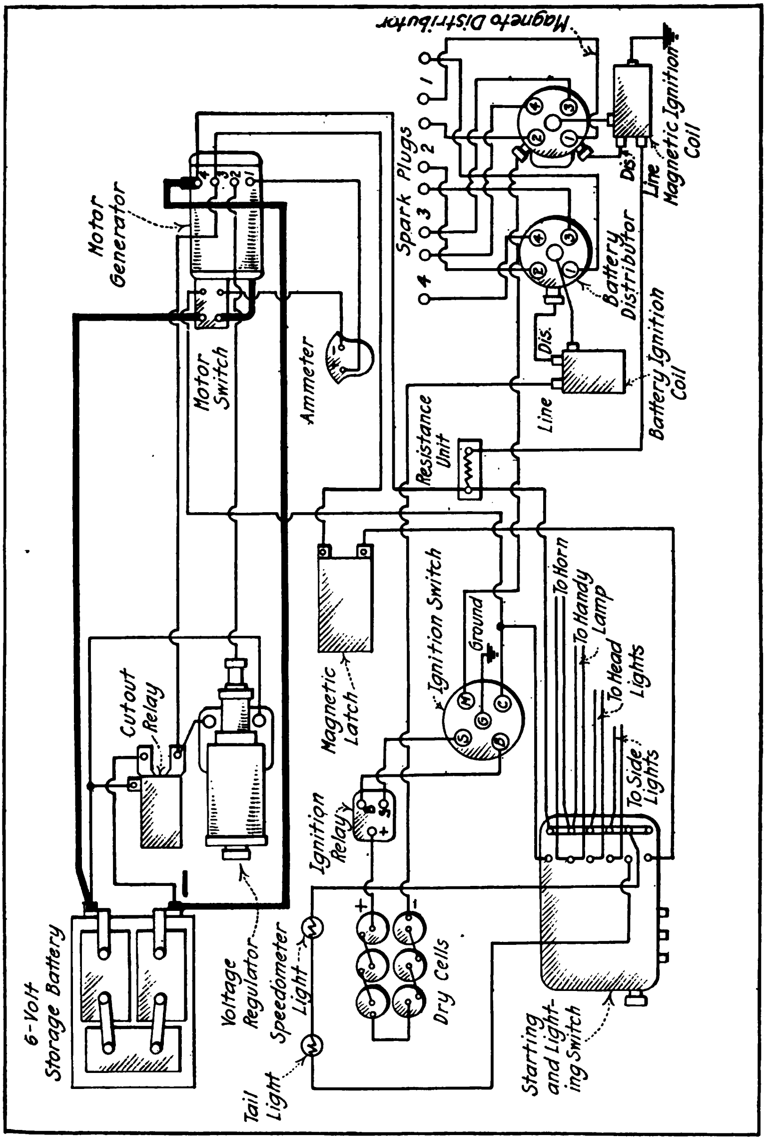

Fig. 268B.—The 1913 Delco Starting, Lighting and Ignition System Fitted to Cadillac Cars Incorporated a Novel Voltage Regulator.

posts will prevent sulphating and consequent corrosion and poor electrical contact at these points. If the electrolyte leaks from the joints, bottom, or wood sides of the battery case, one or more of the hard rubber cells are cracked or broken. The battery must be returned to the factory for repairs or replacement. The metal battery box must be thoroughly wiped out with a cloth saturated with ammonia to neutralize the acid and prevent corrosion. The top of the battery must be kept clean and dry to prevent a leakage of current between the terminals. See that the battery is held securely in its metal box or other container. If necessary pack tightly with waste to prevent the battery shaking about from jolting of the car. Tools, other metal articles, or anything of value should not be placed near the battery as the acid fumes will corrode and destroy metal, cloth and like material. Make certain that the battery terminals cannot touch the cover of the metal battery box. A thin sheet of wood fiber fitted inside the cover of the battery box will prevent short circuits or grounds from this cause. It must be remembered that the efficiency of any storage battery decreases with drop in temperature and it is only about 50 per cent. efficient at zero temperature. For this reason the demand for current should be kept as low as possible in cold weather and lamps turned off when not needed.

The user of any electrical starting and lighting system will avoid trouble and expense by the observation of the following instructions:

Don't replace worn-out brushes with any others than those supplied by the manufacturer.

Don't put oil or grease on the commutator of the generator or motor. No lubrication is wanted there.

Don't turn the hose on the generator or motor when washing your car.

Don't tighten up on the silent chain drive unless the slack becomes excessive from stretching. The chain must be run with a reasonable amount of slack to prevent noise and wear.

Don't fail to lubricate the silent chain drive at frequent intervals. Noise will be eliminated and wear reduced. Keep the chain and sprockets clean, and free from dirt and gravel.

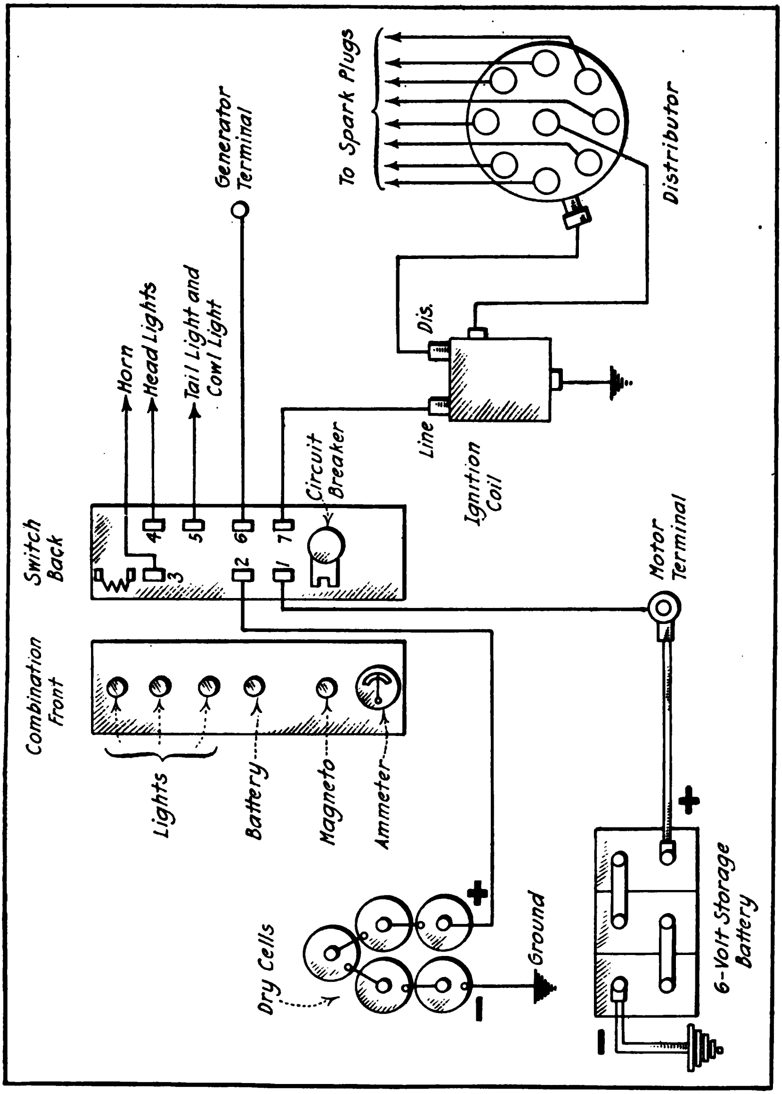

Fig. 268C.—Note Great Simplicity of Delco System Used on the 1915 Cole Eight Cylinder Motor Car.

Don't run your car, if for any reason the battery is disconnected from the circuit, unless you have disconnected the chain driving the generator, or the generator itself has been removed.

Don't attempt to propel car with starter. Such "stunts" are interesting, but expensive. Gasoline is for that purpose.

Don't attempt to make adjustments of any kind in the circuit breaker.

Don't fuss with the system when it is operating properly.

Hints For Locating Delco Trouble.—1. If starter, lights and horn all fail, the trouble is in the storage battery or its connections, such as a loose or corroded connection or a broken battery jar. 2. If the lights, horn and ignition are all O. K., but the starter fails to crank the trouble is in the motor generator, such as dirt or grease on the motor commutator, or the motor brush not dropping on the commutator. 3. If the starter fails to crank or cranks very slowly, and the lights go out or get very dim while cranking, it indicates a loose or corroded connection on the storage battery, or a nearly depleted storage battery. 4. If the motor fires properly on the "M" button, but not on the "B" button, the trouble must be in the wiring between the dry cells or the wires leading from the dry cells to the combination switch, or depleted dry cells. If the ignition works O. K. on the "B" button and not on the "M" button, the trouble must be in the leads running from the storage battery to the motor generator, or the lead running from the rear terminal on the generator to the combination switch, or in the storage battery itself, or its connection to the frame of the car. 5. If both systems of ignition fail, and the supply of current from both the storage battery and dry cells is O. K., the trouble must be in the coil, resistance unit, timer contacts or condenser. This is apparent from the fact that these work in the same capacity for each system of ignition.

Never run the car with the storage battery disconnected, or while it is off the car. Very serious damage to the motor-generator may result from such action.

Never remove any electrical apparatus from the car or make any adjustments without first disconnecting the storage battery. This can be done most conveniently by removing the ground con-

nection. Remember, a loose, corroded or dirty connection on the battery can put both starting and lighting systems out of commission.

The description of the special volt-ammeter shown at Fig. 269, and the methods of using it in looking for derangements in the Delco-motor generator are reproduced from the 1916 Delco-Buick instruction book to insure accuracy in describing these tests. Too

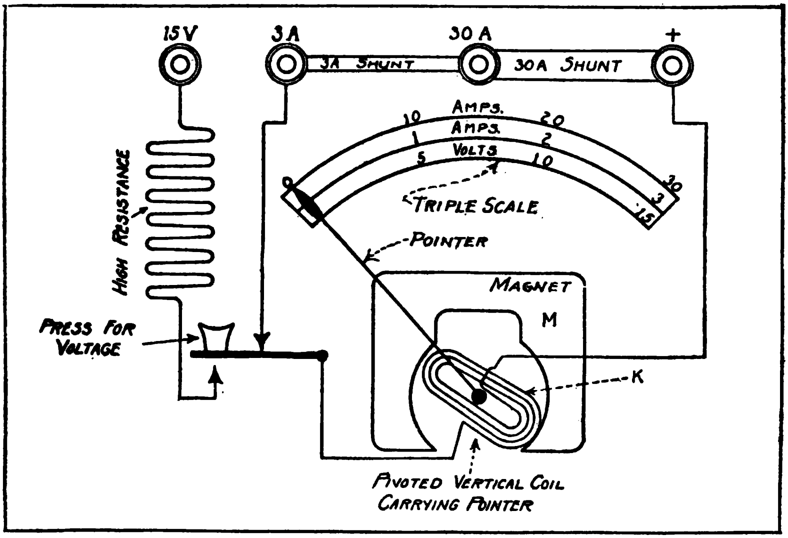

Fig. 269.—Interior Wiring Arrangement of Special Volt-Ammeter, an Important Adjunct to the Testing Equipment of the Delco System Repairman.

often the mechanic is handicapped by not having the proper tools to work with. No mechanic would attempt to overhaul an engine with the tools included in the car equipment, neither should he expect to make all of the practical tests on the electrical system without some additional equipment.

A voltmeter and an ammeter or a combination volt-ammeter is the one most important instrument that the mechanic can use in this work, and in order to explain the action of such a meter,

(Fig. 269) is included. This shows the internal circuits of such a meter with full scale readings of 30 Ampere, 3 Ampere, 15 Volts. The meter proper consists of a permanent magnet "M" between the poles of which is mounted a movable coil "K" which carries the pointer. This part of the meter is very sensitive and carries only a small amount of current. In the average meter with the scale readings as given the current in the different parts would be approximately as follows: With the meter connected to give a full scale reading of 30 amperes (connect the lines to the terminal marked + and to the one marked "30-A") the current would divide at the + terminal, the main part of which flows to the terminal marked "30-A" $29\frac{9}{10}$ amperes flowing in this circuit and $\frac{1}{10}$ ampere flowing through the coil to terminal 3-A through the shunt to 30-A terminal. The $\frac{1}{10}$ ampere through the movable coil is the amount required to give a full scale reading of the pointer.

When the 3 ampere scale is used the current divides at the + terminal and $2\frac{9}{10}$ amperes flows through both shunts to 3-A terminal and $\frac{1}{10}$ ampere through the coil as before. The difference in the proportions of the total current that flows through each circuit from the amount that flows through each circuit in the former case is due to the resistance of the 3-A shunt. When the instrument is used as a voltmeter connections are made to the positive terminal and the terminal marked "15 V" and the button must be pressed. This cuts out the shunts and connects in series the high resistance. This is a very high resistance and when the full voltage reading is taken there is $\frac{1}{10}$ of an ampere flowing through the high resistance and the movable coil, which is the same amount of current that flows in it when it is used as an ammeter and it gives a full scale deflection.

The important points to remember when using an instrument of this kind are as follows: 1. Do not test the storage battery with an ammeter as dry batteries are tested. (This will positively ruin the meter.) 2. In taking an ammeter reading in the circuit where the approximate flow of current is not known, always use the highest scale on the meter and make the connection where it can be quickly disconnected in the event of a high reading. 3. If the

meter reads backwards reverse the wires to the meter terminals. The meter will not be damaged by passing a current through it in the reverse direction as long as the amount of the current is not over the capacity of the meter. 4. No damage will be done by connecting a voltmeter as an ammeter so long as the voltage of the system is not above the range of the voltmeter, but the ammeter should not be used as a voltmeter. 5. A high-class instrument of this type will stand a momentary overload of from 200 to 400%. If the user is careful not to make his connections per-

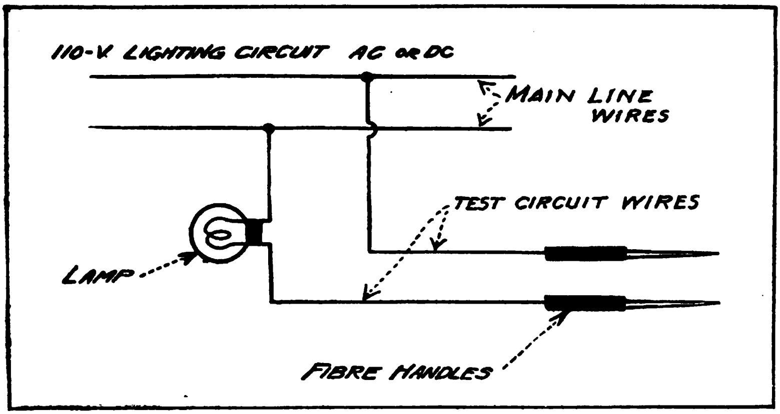

Fig. 270.—Wiring Diagram Showing Methods of Connecting Lamp and Test Points in Lighting Circuit.

manently until the current is normal, he will very seldom injure the instrument.

Next to the combination volt-ammeter the most important testing arrangement for the mechanic is a set of test points to use in connection with the electric light circuit. This is very easily made as shown at Fig. 270 by tapping one wire of an ordinary extension lamp, splicing the wires on to which are attached suitable points with insulated handles in order that these may be handled with no danger of electrical shock. With a set of test points as described the lamp will burn when the test points are together or when there is an electrical connection between the points. This will give more satisfactory results for testing for

grounds, leaks or open connections than will a bell or buzzer used with dry batteries, as the voltage is higher and it requires a small amount of current to operate the lamp. With a bell or buzzer, a ground or open connection may exist, but the resistance is so high that enough current will not be forced through it by the dry batteries to operate the bell or buzzer. No harm can be done to any part of the Delco or other apparatus by tests points as described above, when the ordinary carbon or tungsten lamp is used in testing purposes.

Indications of Delco Generator Troubles.—If there is any derangement of the interior wiring of the Delco motor-generator unit, these defects will be made apparent by: 1st, failure to turn over at uniform speed when starter button is pushed down; 2nd, blackening and burning of the generator commutator or excessive sparking; 3rd, failure to keep battery charged; 4th, slow cranking, even with a well charged battery; 5th, vibration of cut-out relay; 6th, excessive heating of generator. If any of the above indications exist the first step is to go over all connections and make sure if these are made correctly in accordance with the wiring diagram furnished with the car. Examine the commutator to see if it has the same appearance at all points on its periphery or whether some of the segments are burnt more than others. See if the armature will revolve at a uniform speed when the starter button is depressed. If the commutator is burnt black on two or more adjacent segments and it does not revolve uniformly or evenly when the starter button is pushed down, this will indicate that a short circuit exists in one or more of the armature coils which entirely eliminates the action of the winding, so that the armature will revolve only for a fraction of a revolution. It will usually cause the relay to vibrate when the generator is being driven by the engine. If an amperemeter is used in the circuit, the pointer of this will swing back and forth at each revolution both when the engine is turning the generator over and when the current from the storage battery is employed for the same purpose. While a short or open circuited winding is an extremely rare occurrence it may be well to detail the method of testing to see if any grounds or short circuits exist in the armature winding.

Testing for Defective Windings.—In order to make this test intelligently it is advisable to use a 110 volt circuit which includes a 16 candle power carbon filament lamp wired in series and a pair of test points as previously described. Each end of the wire is soldered to an insulated contact point composed of a piece of brass or copper rod having a tapered point attached to an insulating handle of fiber or other non-conductor. The test may be made with the generator in place on the car, if it is accessibly placed or the device may be removed from the chassis. If the armature is in place insulate all brushes from the commutator by placing sheets of waxed paper between them. Then with the test points test for a ground from each commutator segment to the frame or armature shaft as shown at A, Fig. 271. Obviously, if a short circuit exists between any wire and the ground this will complete the circuit and cause the lamp to light. Next with the brushes and commutator bars still insulated as in the first test make a trial for a "short" including the armature and generator windings holding one test point on the segment of the motor commutator and the other on one of the segments of the generator commutator. The lamp should not light during this test, if it does it indicates a short circuit between the two windings. The first test indicates a short circuit between one of the windings and the metal representing the ground, in this case the armature core and shaft.

It may be well at this point to outline the difference between a short circuit and an open circuit. Both of these are clearly shown at Fig. 266. At A, what is technically known as a short circuit is depicted. It will be observed here that the insulation is worn off of one of the wires and that the conductor is rubbing on the metal frame. The positive terminal of the battery is attached to the metal frame and the negative terminal of the battery goes to the current consuming unit, in this case an incandescent lamp. It will be apparent that with the bare wire in contact with the frame that the current will follow the course indicated by the arrows and will return to the storage battery through the ground connection with the bare or grounded wire. In this case no current can flow through the current consuming unit. Owing to the low resistance of the circuit a large amount of current will pass

through and the battery capacity will be quickly depleted. The same condition may exist in the windings of the generator, and if a short circuit is present the current produced by the rotation of the windings will not flow through the external circuit, but will take the shortest way to the ground. A complete open circuit, as indicated at B, permits absolutely no current to reach the lamp. This is because of a positive break in the conductor, which may be produced because of a loose connection or a broken wire. When there is a short circuit, as shown at A, some of the current may reach the lamp filament and cause it to burn dimly.

The location of a fault in a double-function (two commutator) armature is more difficult than finding trouble in a single-function armature, because more things can happen. The method of testing for grounds and shorts has been described. The symptoms and the troubles they indicate in the windings are summarized as follows under the heading of the defective conditions:

Shorted Generator Coil.—Charging rate low; meter vibrates when motoring the generator, or possibly the generator will only turn for a part of a revolution; meter vibrates when engine is running at low speeds; two or more adjacent commutator bars burn and blacken; cranking is slower than normal, but if only one coil is shorted this latter will not be noticed.

Grounded Generator Coil.—This will very seriously affect the cranking, causing it to be slow, and will soon discharge the battery with practically no charge from the generator; will cause burning of the commutator bars; is tested by insulating all brushes from the commutator and testing with the test points from the generator commutator to the frame of the machine. If grounded the test light will burn.

Open Generator Coil.—Charging rate is low; meter vibrates when motoring the generator, and when running at low speeds, the same as with the shorted generator coil; severe sparking at the generator brushes when the engine is running which causes serious burning at one commutator bar. This will not affect the cranking.

Grounded Motor Winding.—This will rapidly discharge the storage battery; is tested by insulating the motor brushes from the

commutator and test with the test points from the motor commutator to the frame. The light will burn if the winding is grounded.

If the cut-out relay points stick, the generator armature will continue to revolve even when the engine is stopped. Smooth the contacts by drawing a piece of very fine emery cloth between them, and be sure that the pivot bearings are free. This will usually cure

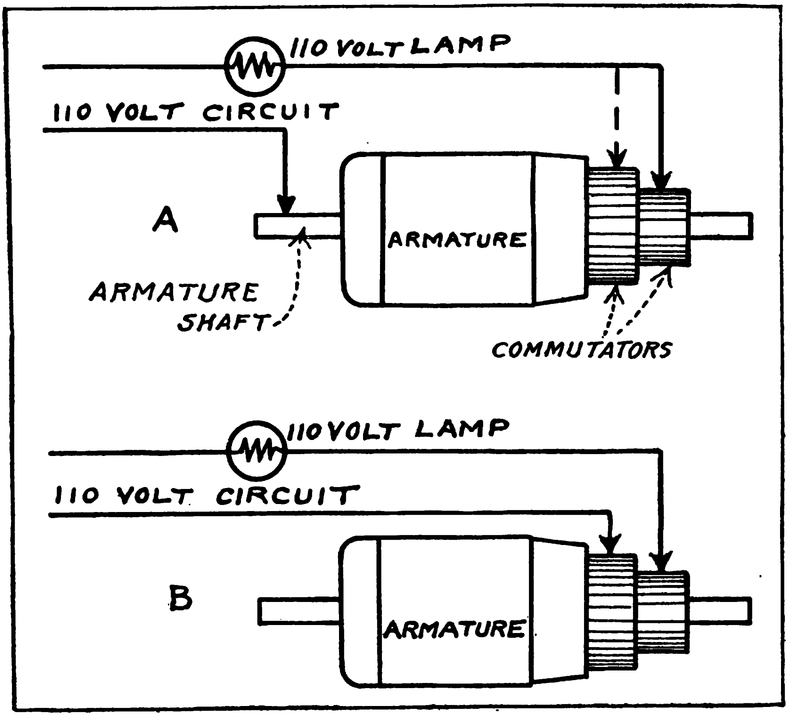

Fig. 271.—Diagram Showing Method of Testing Armature Winding with Test Points for Grounds or Short Circuits.

the trouble, although a sticking roller driving clutch at the forward end of the generator may cause a flow of sufficient current through the relay to give a similar result. The adjustment of the spring tension of the cutout relay should never be made without connecting a volt meter between the proper terminal on the cutout relay and the ground. Start the engine and gradually increase its speed,

and if the spring tension is properly set the relay contacts will close when the meter indicates seven volts. If the relay does not close the contact at seven volts, adjust the spring tension, which may be done by bending the arm at the top to which the spring is attached, using a small pair of pliers for this operation.

If there is any trouble in the voltage regulator the generator will not turn when the starter button is pressed, and the generator will not generate current. To test out the voltage regulator depress the starter button, and if there is sufficient current in the battery and no broken wires and the armature does not revolve, remove the connection to the bottom terminal and voltage regulator and connect it to the terminal above. The armature will now revolve when the starter button is depressed. In order to make repairs replace the regulator tube complete. This can be checked out in another way. When the engine is running at normal speed, see if the cutout remains open. If it does this will indicate a burnt out voltage regulator resistance. If the resistance is burnt out when the lead connecting with the binding post at the bottom of the tube is moved to the upper connection the cutout will immediately be drawn closed and the generator will start to charge the battery. The voltage regulator is not used on all Delco systems, as the third brush system of regulation is used on some cars. The voltage regulator system is used on the 1914 Cadillac, as shown in wiring diagram in preceding chapter, and also in the Cole and Moon cars for the same year. A voltage regulator is found on the 1914 Hudson Six-54, on the 1914 Oakland, Models 43, 48 and 62, on the 1914 Oldsmobile, Model Six-54; the 1915 Oldsmobile Six-55. On the 1915 Buick, Cole, Hudson, Moon, Patterson, and Oakland cars the third Brush System of regulation is used, and is practically the system in general use on 1916 cars because it is a simpler system than that using the voltage regulator.

Ammeter Reading When Motoring Generator.—During the motoring of the generator the pole pieces are magnetized by the current through the shunt field winding. The armature is magnetized by the current through the brushes and generator winding on the armature. It is necessary that current flow through both of these

circuits before the armature will revolve. It is a familiar mistake to think that when current is passing only through the armature the armature should revolve. The shunt field current can be easily checked by disconnecting the shunt field lead from the generator at the ignition coil terminal. The ammeter in this line should indicate approximately 1¼ amperes when the ignition button is pulled out. The ammeter on the combination switch can be depended upon to determine the amount of current flowing through the generator winding during this operation. Both the ignition current and the shunt field current flow through this meter in addition to the current through the generator armature. The timing contacts should be open. This will cut off the ignition current and leave only the armature and shunt field current. Since the shunt field current is only 1¼ amperes the reading of the ammeter will readily indicate whether or not current is flowing through the generator armature winding.

Should it be found that the current through both the armature and the shunt field windings is normal and the armature still does not revolve the trouble may be caused by either (1) the armature being tight mechanically, due to either a sticking driving clutch, trouble in the bearings or foreign particles jammed between the armature and pole pieces. This can be readily tested by removing the front end cover of the generator and turning the armature from the commutator; (2) the shunt field winding or the generator armature winding may be defective in some manner, such as shorted, grounded, or connected to the motor winding. Any one of these would show an abnormal reading of the ammeter in some position of the armature when the armature is revolved by hand. If the ammeter vibrates at each revolution of the armature during the motoring of the generator, and when the engine is running at low speeds, this is very conclusive proof that the armature has either a ground, open coil, shorted coil, or is connected to the motor winding.

If the motor fails to turn the engine when the battery shows that it is properly charged either by specific gravity or meter reading turn on the head lights and then operate the starting lever. If the lights go out, this indicates either a bad cell in the

storage battery or a poor connection either in the plate connectors in the battery itself or at either end of the large cable leading from the battery to the generator. If the light burns brightly, but the motor makes no effort to turn over the engine, the trouble may be caused either by poor contact between the motor brushes and the commutator due to the accumulation of dirt and grease or improper spring tension against the motor brushes. If either of these conditions exist, pressing the brushes more firmly against the commutator will usually result in the armature revolving, proving that the defects enumerated exist.

Voltmeter Test If Cranking Action is Weak.—This cranking current is a heavy discharge on the storage battery, the average car requiring approximately ½ horse power to perform the cranking operation. Nine-tenths of all cranking failures is due either to the storage battery or poor connections in the cranking circuit. The first rush of current from the storage battery during the cranking operation varies from 200 to 600 amperes, depending upon the condition of the engine and the storage battery. This is only a momentary flow of current, but a poor connection prevents this heavy flow of current and prevents the starter from breaking the engine loose. This heavy discharge will naturally cause the voltage of the battery to be decreased, and the amount that it is decreased depends to a great extent upon the condition of the charge of the battery. On a storage battery which is charged so that its specific gravity registers 1200 or more the voltage should not fall below 5 volts.

The voltmeter is the instrument to use to quickly locate the cause for failure to crank. The starter cannot be expected to crank the engine when the voltage falls below 3 or 4 volts. Therefore, a voltmeter should be connected to the heavy terminal on the rear of the generator and to the ground and the starting pedal depressed. If the voltage falls below 4 volts the trouble is either a nearly discharged battery or a poor connection, or possibly a bad cell in the battery. Any one of these can be quickly located by taking individual voltmeter readings of the different cells when the starting pedal is still depressed. If the individual cells show a normal voltage when the starting pedal is depressed then each

connection in the cranking circuit should be bridged by the voltmeter connections. A reading of the voltmeter will indicate the defective connection.

Should the voltmeter indicate a normal voltage from the heavy terminal on the rear of the generator to the ground when the starting pedal is depressed and still the starting motor makes no effort to crank the car, trouble must exist within the generator, such as the motor brush not coming in contact with the motor commutator or dirt or grease on the commutator preventing electrical contact. This could also be caused by trouble in the armature windings, but is very improbable, and can be tested as described.

TROUBLES IN DYNETO SYSTEM

If Dyneto Will Not Start

Do not leave the switch on "start." Turn on lamps, if they burn brightly, try starting again and watch lamps; if they do not drop at all in candle power, it is quite likely that there is an open circuit in the starting wires, switch contacts, terminals or brushes. Be sure that the brushes are not worn out, are free in the holders, and that springs are in condition to press them firmly against commutator.

If, with switch on "START," lamps drop slightly in candle power, and the Dyneto does not start, the trouble may be due to loose connections, rough or dirty commutator, brushes worn out or not well fitted to the commutator, weak brush springs, grounded or defective armature or field windings.

If Lamps Burn Very Dimly or Not at All

If lamps burn very dimly or not at all, when switch is moved to "START," the battery is probably discharged or defective. See battery instructions.

If Dyneto Starts But Runs Too Slowly

Look for high resistance in main circuits, too small wire, loose terminals, bad joints, poor switch contacts, rough commutator, short brushes without sufficient spring tension; also look for weak

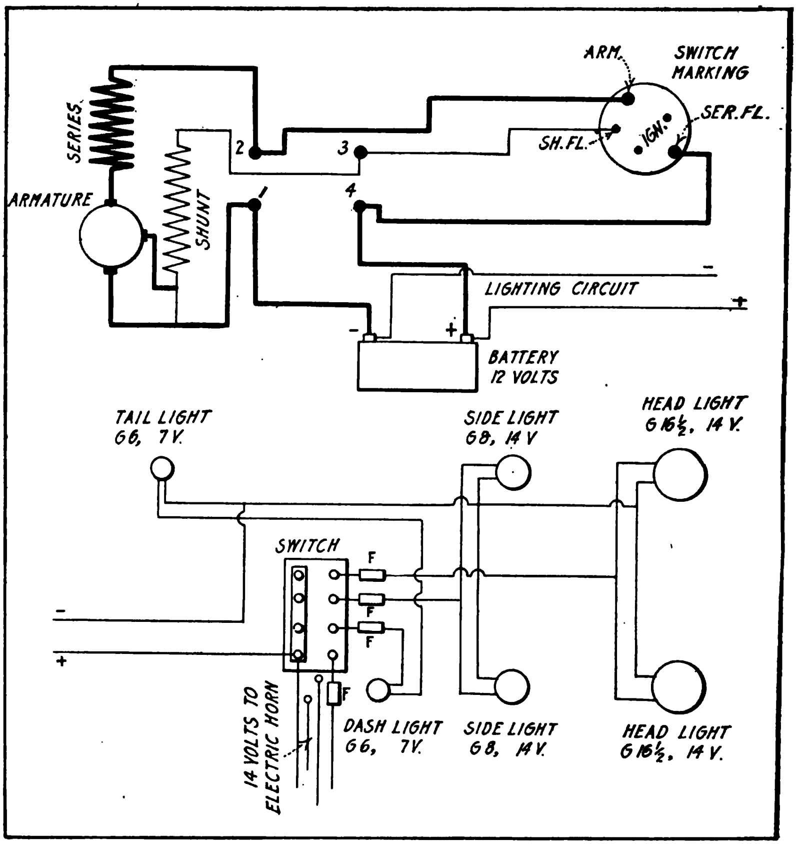

Fig. 272.—Diagram Showing Wiring of Dyneto-Entz Starting and Lighting System.

battery, partially discharged, possibly due to grounds, leaks, unnecessary use of lights when engine is not running or continuous cranking when motor will not "pick up" because of poor carburetion or ignition.

If Dyneto Starts But Will Not Generate

The trouble will probably be found in an open shunt field circuit. This circuit may be traced as follows (see Fig. 272): From negative pole of battery to post 1 through shunt field on Dyneto

to post 3 S H F on starting switch, through switch to SER F, post 4 to positive battery. This circuit may be tested out independently of the main circuit by removing wire from post 2, so as to cut out armature circuit, and setting the starting switch on "START." If the circuit is complete a bright spark will be made when wire is removed from post 3. If no spark occurs, look over all wires and connections, and an open circuit will be found.

If Dyneto Does Not Generate Enough Current

First be sure that the battery is in good condition, and that it utilizes the current actually delivered to it by the generator. (See battery instructions.) If battery is all right, go over shunt circuit as in last paragraph. Be sure that there are no loose connections, and that the commutator is clean and smooth; that the springs keep the brushes pressed against the commutator properly. If an ampere meter is available, connect it to one of the wires leading to the battery. The amount of current that should be generated at various speeds is specified above.

Grounds, Short Circuits, Open Circuits in Lamps and Wire

These troubles are quite common when the wiring is poorly done. Grounds and short circuits often occur in wires not protected by suitable conduit and good heavy insulation, especially when wires pass around sharp corners, over bolt heads, etc. Grounds are also sometimes found in switches, lamps and connectors.

Open circuits may be due to blown fuses, bad joints, poor wiring, loose connections. They are also found in connectors and lamp sockets.

TROUBLES IN BOSCH RUSHMORE SYSTEM

The following instructions regarding the location of trouble in the Bosch-Rushmore starting and lighting system are taken from the Marmon instruction book:

1. *No Lights Obtainable, Car at Standstill*

If lights are obtainable when engine is running, but no lights are available when the engine is at a standstill, this condition

indicates that the battery is either in a totally discharged condition, that the connections to same are loose, or that No. 3 connection to the control box is not making proper contact, or the fuse between positive terminals of the battery and ground is blown or the ammeter shunt is open circuited. If the battery is found discharged, it must be given a charge from an external source. If the connections are loose, re-establish the integrity of the joints. If the fuse is blown, it is necessary to test out the different circuits with either a bell or test lamp before putting in a new fuse. The fuse may have been blown because of a short circuit in one of the circuits and merely replacing the fuse without correcting the faulty circuit would be of little avail. Never use a piece of copper wire in place of a fuse. Always have sufficient fuses for replacement on hand. To determine whether the ammeter shunt is blown or not place the meter handle in the left hand or voltage position. If voltage is obtained move the handle to the right hand position, which is the ampere position. Place the left hand lighting switch handle in No. 1 position; if the shunt is burnt out there will be a violent fluctuation to the left. If this condition exists it will necessitate removing the cover of the control box, uncoupling the two wires that are connected to the connections on the meter and then remove the screws that hold the meter in position. It is necessary to test the wiring thoroughly to locate a ground which might exist and which may have caused the ammeter shunt to blow out. After the ground is located and removed the two wires that were previously connected to the engine can be joined together by means of a small bolt, as this will allow the system to be used while the meter is being repaired.

2. *No Lights Obtainable Under Any Conditions.*

This condition could be caused by any of the foregoing defects, with the addition of No. 1 and No. 2 cables (see Fig. 234) making poor connections either at the dynamo or control box. When making up or replacing terminals used on the cables, use the special wrench supplied with these outfits. It is not necessary to make these tight, as it is only required to tighten the nuts until no more play can be felt by pushing the wire in and out of the nut.

3. *Individual Circuits.*

Bulb filament burnt out; bulb base not making proper contact; cables supplying this circuit loose; the remedy for this is obvious.

4. *Lights Flickering.*

Primarily due to either improper brush contacts, dirty commutator, or loose No. 1 or No. 2 leads, which results in the automatic relay openings and closing with great rapidity. In order to eliminate this, it is necessary to loosen the top screw of end cover of dynamo and turn cover to the left, as far as it will go. This will expose brush holders and commutator. Brushes can be removed by lifting up springs and pushing them to one side. Remove whatever dirt may be on the brushes, in order that they may have a free sliding fit in the brush holders. The sticking of the brushes may have caused the commutators to have become roughened. This can be cleaned by means of fine sandpaper, not emery paper. Never attempt to use other brushes than those supplied by the Bosch Company. If the flickering is intermittent, it is caused by loose connections on the battery side of the system.

5. *Lights Dim (Individual Circuit).*

Poor lamp contact or poor cable contact; remedy obvious.

6. *All Lights Dim (Car Standing Still).*

Battery partially discharged; partial ground or short circuit. First determine the condition of the battery as cited under "battery" heading. If this is found to be O. K., test each individual circuit for ground. This can be done by disconnecting them all at the control box, and replacing them one by one, and note at which circuit the lights dim. This will be the circuit that the trouble exists on, and the cable terminals and cable itself should be thoroughly examined.

7. *Lights Dim (Engine Running).*

Dynamo not operating with a partially discharged battery. Dynamo and battery condition O. K. with a heavy ground or short circuit on system; starting switch not having returned to the off position. To remedy, proceed as under heading "no lights obtainable."

8. *Dynamo Not Cutting In Until High Speed Is Reached.*

If the dynamo should not cut in until the engine is raced, and after it once cuts in it operates satisfactorily even down to low car speeds, this is an indication that the dynamo brushes are not making proper contact, or that the commutator is roughened and dirty. To remedy, proceed as under "lights flickering."

9. *Adjustment of Automatic Relay.*

Before proceeding with the method of adjusting and regulating the automatic relay or cutout, and the voltage regulator or controller, it should be borne in mind that these parts are correctly set and adjusted before leaving the factory, and no attempt should be made to alter same, unless you are certain that conditions can be bettered or corrected by doing so. These parts will operate over great lengths of time with absolutely no attention, and they should be touched only when you are positive that the difficulty lies there.

This relay is for the purpose of closing the dynamo circuit on to the battery when the dynamo voltages are correct. If it is necessary to alter this cutting-in point, it is done by slackening off the hexagon-headed nut at the buttom of the left-hand relay. To cause it to cut in at a higher voltage, this nut should be tightened. To cut in at lower voltage, it should be slacked off. Do not forget to tighten up on the lock nut. In the front and toward the bottom of the relay, an opening is noticed. When this relay is closed, there should be a gap of approximately $1/64$ of an inch between the movable member of the cutout and the stationary part. To adjust this distance, it is necessary to alter the position of the contact, carried on to the bridge, located on top of this relay. This is done by slackening off the hexagon jam nut and backing the contact screw down.

10. *Adjusting Regulator.*

The regulators when sent out are adjusted at a point to give the most satisfaction over the most general average operating conditions, but some individual cases may be brought to your attention which will necessitate altering the regulation. This is accomplished by means of altering the position of the conical-

headed screw at the top of the right-hand relay. This is done by means of a small socket wrench. By causing the screw to travel so that a greater pressure is exerted on the small pin underneoth the conical head, it results in a higher voltage at the dynamo terminals, and slackening off this screw decreases this pressure, and results in a lower voltage. The adjustment at all times should be so that the battery is maintained at approximately 80% charged, but at no time should the regulator be set so that the dynamo voltage just previous to the automatic relay operating is more than 14¾ volts, inasmuch as this would cause a violent change in the intensity of light, when the automatic relay operated.

No mention has been made in these instructions of the right-hand switch on the control box. This was purposely left out, inasmuch as the switching combination has been changed, and this switch is now inoperable. The dynamo and the battery are always in parallel with the automatic relay or cutout contacts in series.

If Starter Will Not Turn Motor.

1. See that starter pedal is not sticking and goes all the way down. Disconnect storage battery under seat, if pedal sticks.

2. Note whether starter gear goes into engagement. If starter spins, "nurse" the pedal until gear engages.

3. See that main leads between battery switch and starter are firmly connected, especially at the battery.

4. Battery may be discharged. Test gravity per separate instructions.

5. Start with crank and report promptly to Bosch or Marmon representatives.

If Starter Turns Motor, But Motor Will Not Fire.

1. Do not continue to "churn" motor, but check over motor conditions. See that—

Ignition switch is in proper position.
Throttle lever is open about one and one-half inches.
Air choke lever is closed (in cool or cold weather).
There is gasoline in the carburetor.
Gasoline line cock is open.

2. With a very cold motor it may take some time to get an

ignitable mixture into the cylinders, but if the air choke valve almost entirely closes the carburetor intake a strong suction will draw gasoline into cylinders as effectively as priming. In extreme cold weather a prompt start will follow wrapping a hot water-soaked cloth about intake manifold.

3. In moderate weather continued churning with the air choke closed will cause cylinders to flood. To clear motor open wide the air choke and throttle levers. If still unable to get an explosion, do not continue to apply starter, but look for the trouble.

4. See that carburetor is getting its supply of pure gasoline.

Drain vacuum feed reservoir and note carefully whether there is dirt or water present.

If so, drain carburetor and fill reservoir by revolving motor with starter with air valve closed.

Then see that you are getting good gasoline and you will get a start.

If you cannot get gasoline to flow, water may be frozen or line may be choked with sediment.

If gasoline supply seems all right, turn to ignition.

5. See whether you get a spark at spark plugs when cranking by placing a screw driver or other metal from metallic connection on top of plug to metal on motor. If not—

Disconnect magneto ground switch wire. If it then fires, this wire is grounded somewhere, causing the trouble.

If not—

Remove and inspect distributor.

See that breaker is working.

6. If you get a good spark, examine the spark plugs. They should have a gap of .025 inch (eight thicknesses of this paper).

See that they are free from soot.

See that porcelain is not cracked.

TROUBLES IN REMY STARTING, LIGHTING AND IGNITION SYSTEMS.

The diagrams presented in preceding chapter should make clear the various connections of this electrical system and a review of the following suggestions for locating trouble, which are taken from

the instructions of the Remy Company will enable the reader to remedy any defective condition that might materialize.

Grounds and Short Circuits.—It is readily seen, by a glance at these diagrams, that this is what is known as a one-wire system, that is, the bodies of the machines, the engine and the frame of the car form one-half of the circuit between the battery and the motor, ignition-generator, ignition switch, and lamps. Thus it will be seen that if the insulation is worn off any one of the wires and the copper touches any of the metal parts of the car, a short circuit will result, which will either render the system inoperative by blowing out one or both of the fuses or will discharge the battery. Short circuits may result from two bare wires coming into contact, but in general where short circuits are mentioned in this book a contact of a bare wire with some of the metal parts of the car is referred to. By "open circuits" is meant broken wires, fuse burnt out, or proper connections not made to the frame. It should be borne in mind that inasmuch as the frame of the car forms one-half of the electrical circuit between the lamps, the ignition switch and the battery, the frames of the lamps and the proper terminals of the ignition switch and battery should be well grounded to the frame of the car at all times.

All Lights Go Out—Ignition Fails—Starting Motor Dead.—The cause of this is: (1) A loose connection either at battery terminals, at battery side of starting switch, or at point where battery is grounded to the frame of the car. (2) A loose connection at motor side of starting switch or at starting motor and the wire between the switches broken. (3) Loose connection at motor side of starting switch or at starting motor and the Model 79 fuse burnt out.

All Lights Go Out—Ignition Fails—Starting Motor O. K.—A short or open circuit in the wire between the starting switch and the Model 79 fuse block or the Model 79 fuse being burnt out might be the cause of this. Look first to see if this fuse is intact. If the fuse is burnt out make a careful examination—for grounds—of the wiring between the Model 148 switch, the lamps and the ignition distributor before replacing with new fuse. See that all connections on the fuse block and the back of the Model 148 switch are tight.

All Lights Go Out—Ignition and Starting Motor O. K.—It is evident that this trouble is confined to open circuits between the lighting switch and the lamps, loose connections at lighting switch or at lamps, or burned out bulbs.

Ignition Fails—Lights and Starting Motor O. K.—This trouble may be traced to loose connections at the ignition switch, coil or ignition distributor, poor grounding of the switch on the speedometer support screw or open circuits or short circuits between the ignition switch and distributor. See that the contact points in the breaker box are adjusted correctly and examine all high tension wires.

All Lights Go Dim.—A short circuit between the battery and starting switch or between the starting switch and ignition generator would cause this trouble. The most probable cause is a discharged battery resulting from leakage of current due to short circuits in the wiring; using bulbs of higher candle-power than those recommended; using low efficiency carbon filament bulbs, or defects in the generator which prevents it from charging properly. Make sure that the generator protective fuse on the relay regulator base is not burned out. Another possible, though hardly probable, cause is that the relay points might remain closed. This would cause the current from the battery to be dissipated in the windings of the ignition generator. If this is the case the cover may be removed and the contact broken by releasing the relay blade with the finger. If the contact points are roughened or pitted, draw a piece of very fine sandpaper lightly between them and carefully remove all dirt or dust. If the generator protective fuse is intact and the ignition generator is not charging properly, the relay-regulator cover should be removed and all contact points examined to make sure that they are not kept separated by some small particle of foreign matter that is not capable of conducting electricity. A small quantity of dirt between the points will keep the generator current from flowing to the battery, and will naturally produce a discharged battery in time.

Generator Test.—A simple test to determine if the ignition-generator is properly operating is first, switch all lights on with engine idle; second, start engine and run same reasonably fast.

If lights brighten after starting engine, it proves that the ignition-generator is properly delivering current. This test must necessarily be conducted in the dark, either in garage or, preferably, at night time.

One Light Goes Dim.—The more probable causes of this are a defective bulb or connection at the lamp. If these are O. K., make an examination for short circuits in the wiring to the lamp.

One Light Flickers.—Loose or frayed connection at lamp or at switch. An intermittent ground or short circuit in the wiring to the lamp. Bulb loose in socket.

Tail Light Goes Out.—Look first for a burned out bulb. Then see that the wire to the lamp is not broken, that connections at switch and lamp are tight and that the body of the lamp is making good electrical connection with the frame of the car.

Cowl Light Goes Out.—Make an examination, same as in preceding paragraph, of cowl light circuit.

Head Lights Go Out.—Make same examination of head light circuit.

One Head Light Goes Out.—It is evident that this trouble is confined to an open circuit between the junction A and the lamp, bad connection at lamp, burned out bulb or frame of lamp not grounded properly.

Starting Motor.—The closing of the starting switch completes the circuit and puts the starting motor in operation. If it does not spin the engine, release the switch at once, ascertain if all connections are tight and secure, that the motor brushes are bearing on commutator properly, and inspect the battery. If the starting motor turns the engine over very slowly, it is evident that the battery is weak or engine exceptionally stiff, for some reason, probably overheating or lack of lubricant.

If the starting motor is spinning the engine at a reasonable cranking speed and the engine does not fire, remember that the starting motor is performing its duty, so do not let it continue to spin the engine longer than necessary as a needless drain is placed upon the battery. If the engine does not fire, it is evident that the trouble is confined to carburetor or ignition, and the failure to start is no fault of the starting system.

Instructions for Repairing Storage Battery.—In repairing a Willard storage battery a definite routine must be followed in tearing down and building up same in order that it will be in the best condition when re-assembled. (See Fig. 273.) These steps are as follows:

First: Remove all vent plugs and washers.

Second: Centerpunch both top connectors in each cell which is to be repaired; then drill ¾-inch into top connector, with a ⅝-inch diameter drill. Now pull off top connector with pair of pliers.

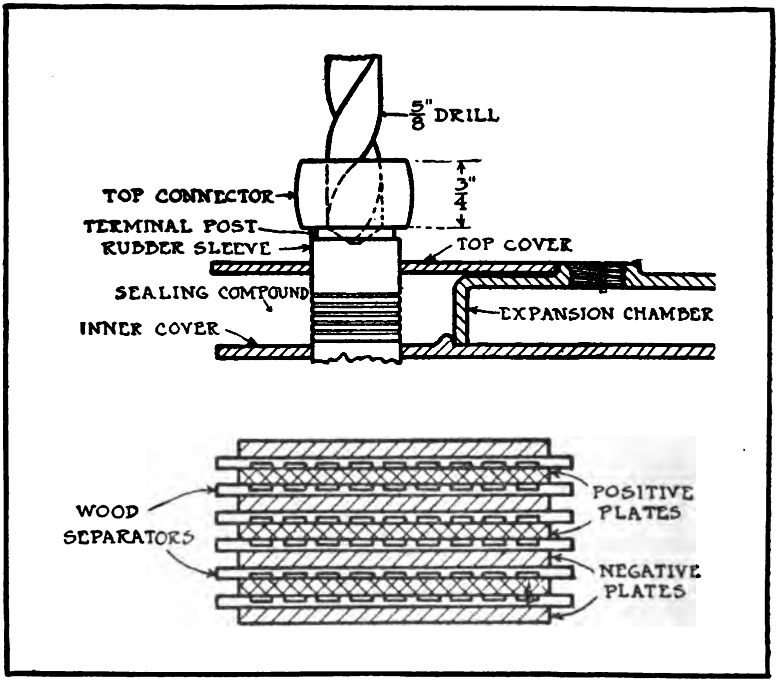

Fig. 273.—Method of Drilling Into Terminal Post of Willard Battery and How Plates and Separators are Assembled.

Third: Apply gas flame or blowtorch flame to the top of the battery long enough to soften the sealing compound under the top cover. Now, with heated putty knife, plow out the sealing compound around the edge of top cover.

Fourth: Insert a putty knife, or any other thin, broad pointed tool, heated in flame, along underside of top cover, separating it from the sealing compound. Then with putty knife, pry the top cover up the sides and off of the terminal posts.

Fifth: Then, with heated putty knife, remove all sealing compound from inner cover.

Sixth: Now play the flame onto the inner cover until it becomes soft and pliable; then take hold of both terminal posts of one cell, and remove the elements from the jar, slowly; then lift the inner cover from the terminal posts.

Seventh: Now separate positive and negative elements, by pulling them apart sideways. Destroy old separators.

Eighth: To remove a leaky jar, first empty the electrolyte from the jar, and then play the flame on the inside of the jar until the compound surrounding it is soft and plastic; then with the aid of two pairs of pliers, remove it from the crate, slowly, lifting evenly.

Ninth: To put in a new jar, in place of the leaky one, heat it thoroughly, in a pail of hot water, and force in gently.

Tenth: In re-assembling the battery, first assemble the positive and negative elements, pushing them together sideways; then turn them on the side and with both hold downs in place, insert new separators, being very careful to have the grooved side of the separators next to each side of each positive plate. Also be careful to have the separators extend beyond the plates on each side, so there will be no chance of the plates short-circuiting. Now press all separators up against hold downs.

Eleventh: Heat up inner cover with flame; then place same on terminal posts; then take hold of both terminal posts and slowly lower the elements into the jar.

Twelfth: Now, with expansion chamber in place on the inner cover, pour the melted sealing compound on to the inner cover, until it reaches the level of the hole in the top of the expansion chamber,—*i.e.* so that when the top cover is replaced, it will squeeze the sealing compound off the top of the expansion chambers.

Thirteenth: Now soften top cover with flame and replace on terminal posts until it rests on top of expansion chamber; then place a weight on top cover until sealing compound cools.

Fourteenth: Now, four sealing compound around the edge of the top cover, until it reaches the top of top cover; then when the sealing compound has cooled, take a putty knife and scoop extra sealing compound off of top cover, making a smooth surface over all the top of the battery.

Fifteenth: In burning the top connector to terminal post, proceed as follows: Scrape the hole of the top connector until the surface is bright and clean; scrape terminal post until top and edge are bright and clean. Now, scrape a piece of lead—preferably a small bar—bright and clean; then apply hydrogen gas flame, mixed with air under pressure, to the top connector and terminal post assembled, at the same time heating lead bar. When top connector and terminal post begin to melt, apply lead bar directly on same, melting it, thus making a firm burned connection. Then fill rest of hole-space with melted lead and smooth off even with top of top connector.

CHAPTER VII

MISCELLANEOUS ELECTRICAL DEVICES

Non-Glare Devices—Electrical Alarms—Electrical Signals—Gear Shifting by Electricity—Electric Brake—Carburetor Warmer—Electric Vulcanizers —Entz Electric Transmission—Novel Lamps and Miscellaneous Devices.

Glaring Headlights.—Speaking of glaring headlights, the cause and elimination or reduction, a writer in Horseless Age discourses as follows: Even when acetylene head lamps were still commonly used on automobiles, there was considerable objection to their blinding glare, and many drivers in the big cities then pasted translucent paper to the back of the lenses or glasses, or gave the lenses a coating of paint, except for a small central circle. When the still more powerful electric headlights became popular, so much annoyance was caused to pedestrians and drivers that several municipalities took action in the matter. One of the first cities to prohibit the use of glaring headlights in its streets was Chicago, whose ordinance provides in substance that "it shall be unlawful for any person operating an automobile to use a bright headlight, unless such headlight be properly shaded so as not to blind or dazzle other users of the highway." The New York City ordinance contains practically the same provision. The city of Cleveland has adopted an ordinance providing that at a distance of seventy-five feet or more ahead of the vehicle none of the reflected light from a headlight must be visible more than three feet above the roadway. A similar law is in force in the State of New Jersey.

It would thus appear that the problem can be solved in two essentially different ways. Either the light must be dimmed as a whole or else it must be tilted or shaded in such a manner that none of its reflected rays can rise beyond a certain height. In this connection it may be well to explain what is meant by "glare,"

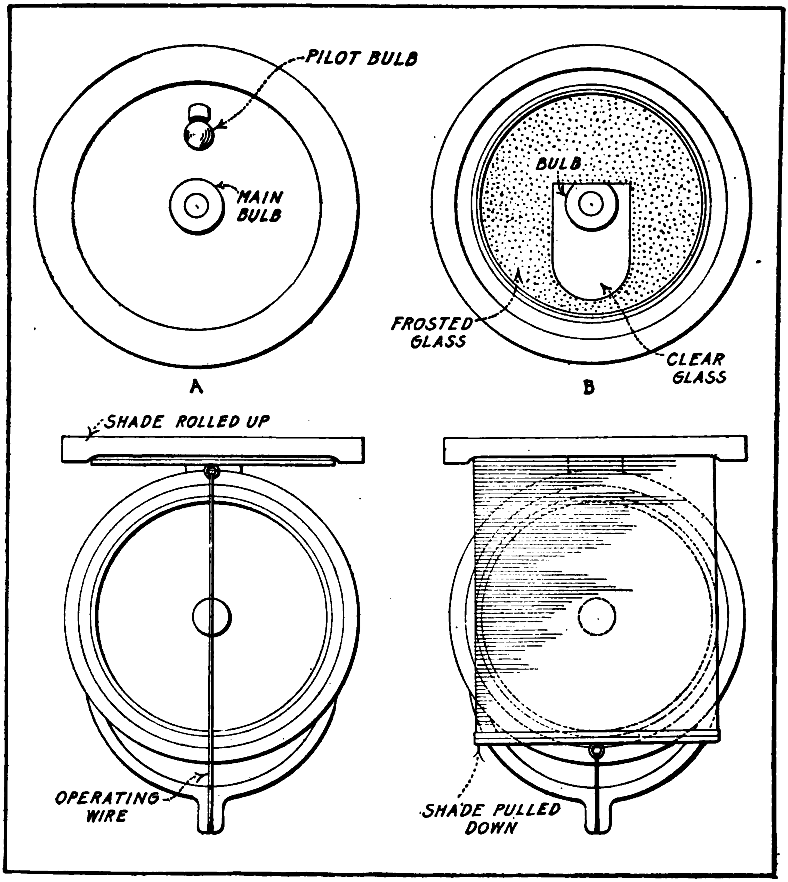

Fig. 274.—Simple Methods of Eliminating Headlight Glare.

the term most frequently used to express the blinding effect of powerful headlights. Perhaps the best definition yet given is the following: "A glaring light is one which interferes with the acuteness of vision of adjacent objects." Glare is due chiefly to the ultra violet rays of the spectrum. It has therefore been proposed to use a yellow lens or front glass on head lamps, which absorbs the ultra violet and blue rays and transmits only red, orange, yellow and green rays. This special glass used for the purpose

transmits the red and other rays with very little absorption, hence the total radiation is not materially reduced. Another fact to be taken into account is that the red rays penetrate farthest through a misty or foggy atmosphere, as is shown by the fact that the sun when rising or setting always appears red. Hence the penetration of the beam of the headlight is not much, if any, diminished by the yellow glass.

Methods of Reducing Glare.—By using two bulbs in the headlights, a larger one in focus and a smaller one out of focus, as in the Gray & Davis lamp shown at A, Fig. 274, both an intense light for country driving and a subdued, non-glaring light for city driving can be obtained from a single lamp without any shading device and without waste of current. This arrangement gives the car the equivalent of both head and side lights, reducing the side lamps to the small bulbs.

Another principle which may be employed for preventing annoying glare is that of making certain portions of the front glass of such form that they will disperse the rays falling upon them, rather than transmit them without deflection. Thus by making the top half of the glass of grooved or corrugated form the top half of the beam will be broken up and only the bottom half remain, and the lamp can then be so adjusted on its bracket that no part of the beam rises more than a certain height above the road surface. This principle of limiting the maximum height of the shaft of light works all right on level ground but it is ineffective when a car approaches the crest of a hill, which is one of the critical conditions in night driving. In such a case it would certainly be better if the driver had some means at his command for instantly reducing the intensity of the projected beam. Sometimes the lamp is provided with a frosted glass, having only a small portion of clear glass as shown at B, Fig. 274.

An early method of dimming electric headlights consisted in reducing the voltage applied to them, either by connecting the two lights in series across the battery or by introducing a resistance in the circuit. Connecting the lights in series is advantageous on account of the current economy resulting therefrom. There is one objection to it, however, namely, that in case one filament breaks,

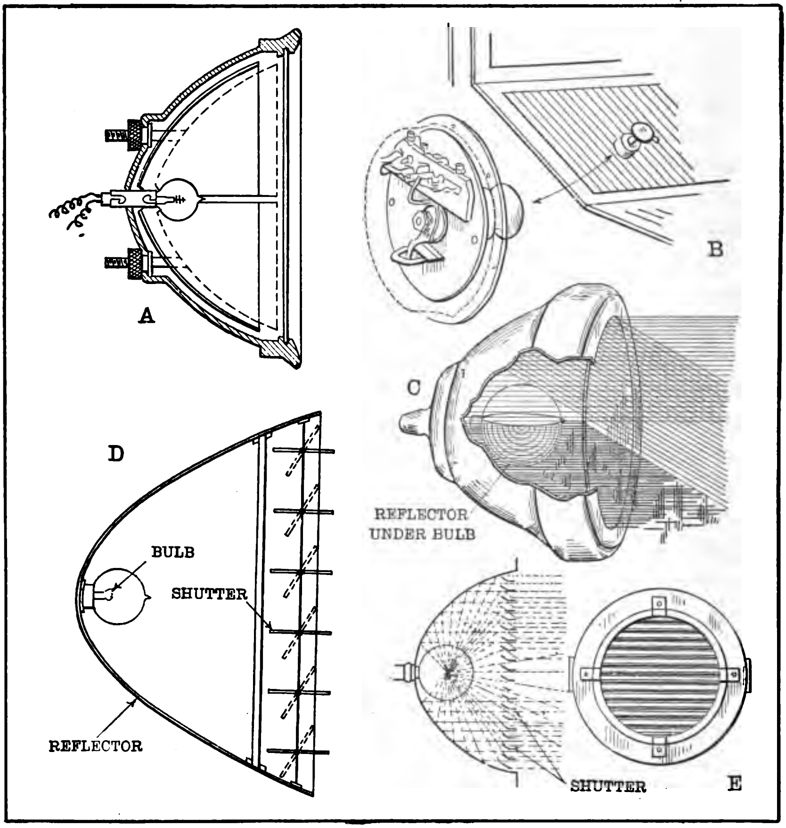

Fig. 275.—Miscellaneous Fittings to Use in Connection with Electric Headlights to Reduce Objectionable Glare.

both lamps will go out instantly and the driver, therefore, will be enveloped in more or less darkness. This, however, is a less serious matter in city driving than it would be in country driving, because of the street lighting.

Another dimmer consists of a shade of translucent material, as depicted at the bottom of Fig. 274, similar to a window shade, which is rolled up in a tube above the lamp when not in use and is drawn in front of the lamp by means of a cord connection

to a foot-operated device when it is desired to dim the lights. When the foot pressure is removed from the pedal a spring automatically rolls up the curtain in the tube.

The method shown at A, Fig. 275, involves the use of a lamp with a readily movable reflector which can be moved out of focus with respect to the bulb for city work, or where the anti-glare laws are stringent. When the searchlight effect is wanted it is very easy to bring the reflector in focus again. A foot-controlled form of dimming switch is shown at B. This is intended to be placed under the toe board, having the plunger project through where it can be easily depressed. Such devices may work either by interposing a resistance in circuit or by coupling the lamps in series momentarily.

The Amco auto light deflector, outlined at C, is a small white enamel reflector that is snapped on the lower side of an electric bulb. It deflects all light rays to the upper half of the lamp reflector from which they are cast outwardly and downwardly, as at Fig. 276, and eliminating all glare. By this principle the strength of the light is not decreased, the road being as well illuminated as before.

The Amco auto light deflector adequately meets all laws governing headlights and has been highly recommended by experts. The Department of Motor Vehicles of the State of New Jersey is one of the latest indorsees.

The use of shutters or curtains naturally suggests itself, and a number of dimmers of this class have been brought out. The No-Daz, shown at D, Fig. 275, consists of a series of translucent screens which normally stand parallel to the axis of the beam of light so as not to obstruct the light, but upon pushing a button which energizes an electro-magnet, they are placed at right angles to the beam of light, thus placing a curtain of translucent material in front of the lamp. The apparent source of light is then a circular plane of considerable diameter, which gives a mellow, diffused light claimed to be sufficiently strong for driving at ordinary speeds and unobjectionable to other road users. The operating mechanism consists of a small solenoid placed out of sight close to the screen.

The Aderente, illustrated at Fig. 275, E, is a non-blinding device which is so arranged as to cut out the glare and at the same time have many of the rays of light thrown directly ahead of the car in order to illuminate the roads. According to the manufacturer the device is not a dimmer, but rather increases the power of the projected light by deflecting the rays to the road which would otherwise be thrown upwards or in a straight line ahead of the car, thereby blinding approaching pedestrians or drivers. The device is attached to the lamp door, and although made of metal, is said to have the appearance of cut glass. It does not require adjustment and does not have to be touched whether the car is being driven through the city streets or in the country. As the device is attached inside the door, it should not require frequent cleaning.

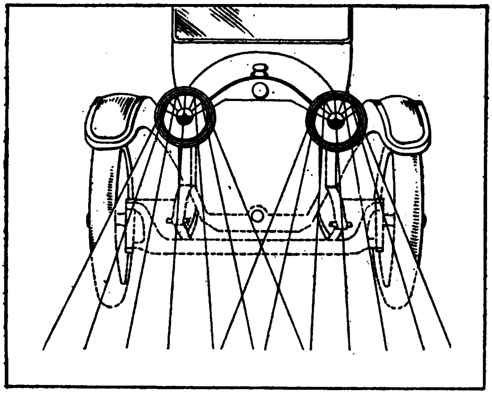

Fig. 276.—Illustration Showing How the Use of Shields Under the Lamp Bulbs Reduces Glare by Deflecting the Light Rays to the Ground.

Electrical Alarms.—The old style hand-operated bulb horn has given way to the more easily actuated electrical signals since the use of electrical current has become general in the modern automobile. These signals operate on two principles: they may be the buzzer type, as shown at Fig. 277, A and B, or may be of the form having a mechanically actuated diaphragm, as shown at C and D. The buzzer type horns actuate the diaphragm by magnetic attraction just as an electric bell hammer is actuated by the magneto. In one form the diaphragm is attracted directly by the magnet, in the other, shown at B, the sound-producing element is vibrated by a plunger rod attached to an armature. The mechanical type in which the diaphragm is moved by a ratchet wheel is

the most popular type, and makes the most penetrating noise. The sound of a buzzer type horn may be regulated by the adjusting screw provided for the purpose.

A motor-driven warning signal is the latest addition to the Stewart accessory family. The motor is very simply arranged, with the ratchet rotor on the end of the armature shaft and

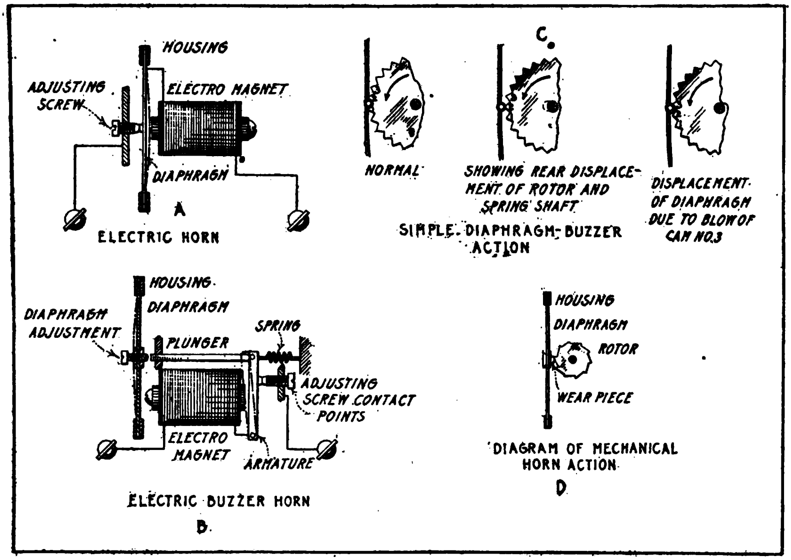

Fig. 277.—Diagram Showing Construction of Electric Buzzer and Other Mechanical Horns.

bearing directly against a stirrup on the diaphragm. This arrangement provides a very simple and direct mechanism for producing the sound. A feature of the instrument is that the motor is completely assembled in itself and can be slipped directly into the housing of the warning signal. With this arrangement, the bearings are always in alignment and the friction and resistance are cut to a minimum. The front bearing at the rotor end is a bronze bushing, while at the other end there is a ball thrust X, as shown in the illustration Fig. 278. The lubrication of the instru-

ment is taken care of by a ball oiler which provides a passage directly to the armature shaft.

Some of the advantages claimed for the instrument by the manufacturers are light weight, high speed with small amperage, water-tight winding, firm fastenings to resist centrifugal force, hard drawn copper commutator and the winding which is so ar-

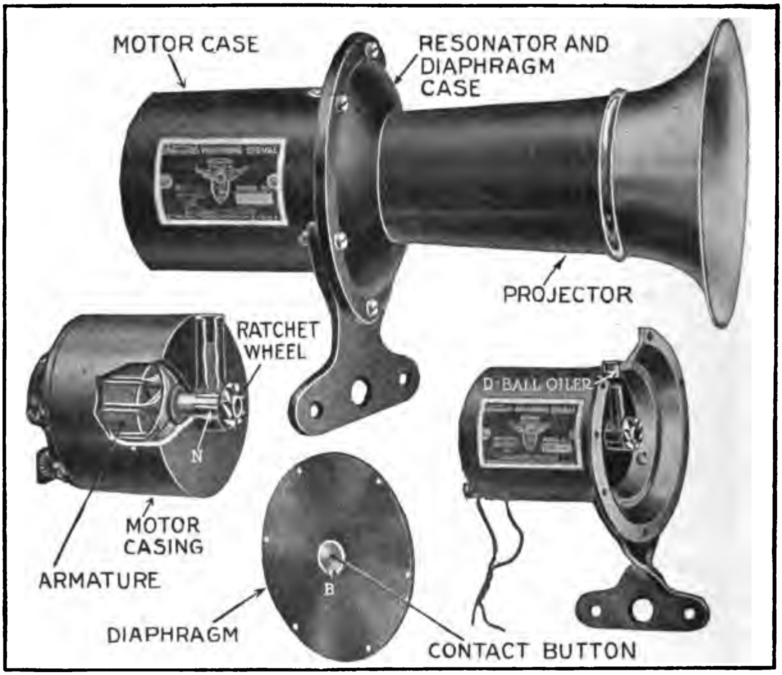

Fig. 278.—The Stewart Electric Motor Driven Warning Alarm.

ranged as to provide maximum saturation of the fields. The tone of the signal may be adjusted by a sounding button in the center of the diaphragm.

Direction Indicators.—In any city where there is considerable traffic, there is always the liability of a car colliding with one that has suddenly stopped without giving due notice of the fact to those following. A number of electrically operated direction in-

dicators have been devised to give notice of an intention to stop or to turn with a view of eliminating danger of collision. Typical devices of this nature are shown in Fig. 279. The Warner device shown at A is a very neat and easily installed form. The external appearance of this device is made clear by the photograph, which also shows its size, by comparison with the standard number plate. The outer case is brass, and inside there is a glass cylinder divided

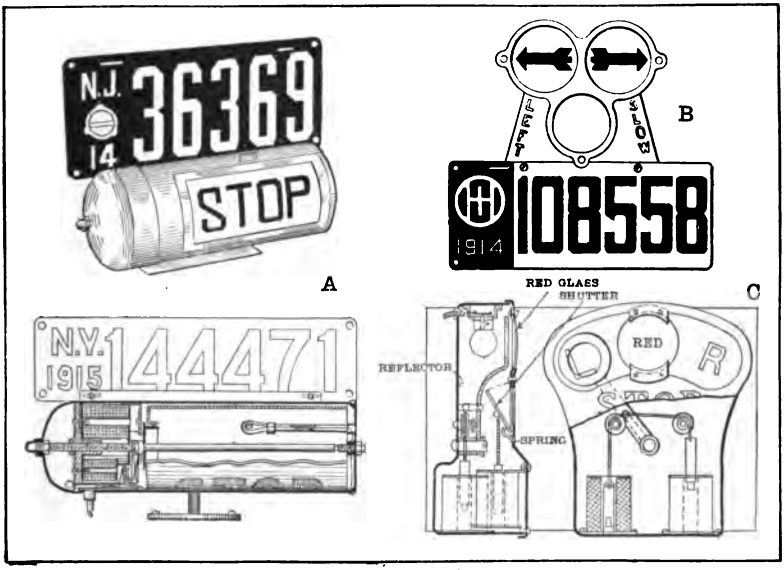

Fig. 279.—Views Showing Construction of Electric Signals for Use at the Rear of the Car.

into four sections, one bearing the word "Stop," another colored plain red, and the other two labelled "Turn," bearing arrows pointing to right and left respectively. At the end of the case there are three magnets which can be caused to pull around an armature and turn the glass cylinder more or less according to which magnet is energized. In the section this armature is shown hanging in the bottom position to which it returns by gravity when the magnets are deenergized. The lamp is accessible from the end of the case, and there is a long, narrow window along the top of

the case through which a shaft of light illuminates the registration plate.

It is recommended that the control be both by finger-operated switch and by connection to the brake pedal for bringing the "Stop" signal into play. Normally, when there is no current in any magnet and the armature lies at the bottom, it is the plain red section of the glass cylinder that is opposite the rear window, and this acts as a tail light. A bell forms the left end of the outer case, as can be seen in the cut, and this is arranged to ring every time the signal is operated.

The Safetylite is the name of a rear signal recently put on the market shown at Fig. 279, B, which indicates the direction in which a car is going to turn as shown in the accompanying illustration by means of arrows. The device consists of an aluminum casing containing electric bulbs controlled from the dash or steering wheel. The light from the bulbs brightens either the right or the left arrow so as to render it clearly visible to a driver in the rear. The signal is fitted with a standard license-plate bracket.

The Pomeroy signal is shown at C. This also provides the red rear light and also indicates Left, Right and Stop. The drawing shows electrical operation, there being three solenoids; two operate the swinging indicator lever to show L or R and the third controls a shutter which normally covers up the stop signal. Electric contacts are arranged on the steering wheel so that movement in either direction swings over the right and left lever, and for the stop signal there is a separate push button.

The Vulcan Electric Gearshift.—A new system of gear shifting has been recently developed which depends on the use of electric current to shift the gears instead of the usual hand lever. The steering wheel is shown at Fig. 280, with the various speed-changing buttons let into a box attached to the steering post while the wiring is as outlined at Fig. 281. The operation of shifting a gear is very simple, consisting merely of depressing the clutch pedal and pressing down on the switch button marked with the gear ratio desired. The system is not complicated, the gears being controlled by solenoid coils, one being used for each forward speed and one for reverse. Two switches are utilized between the battery and

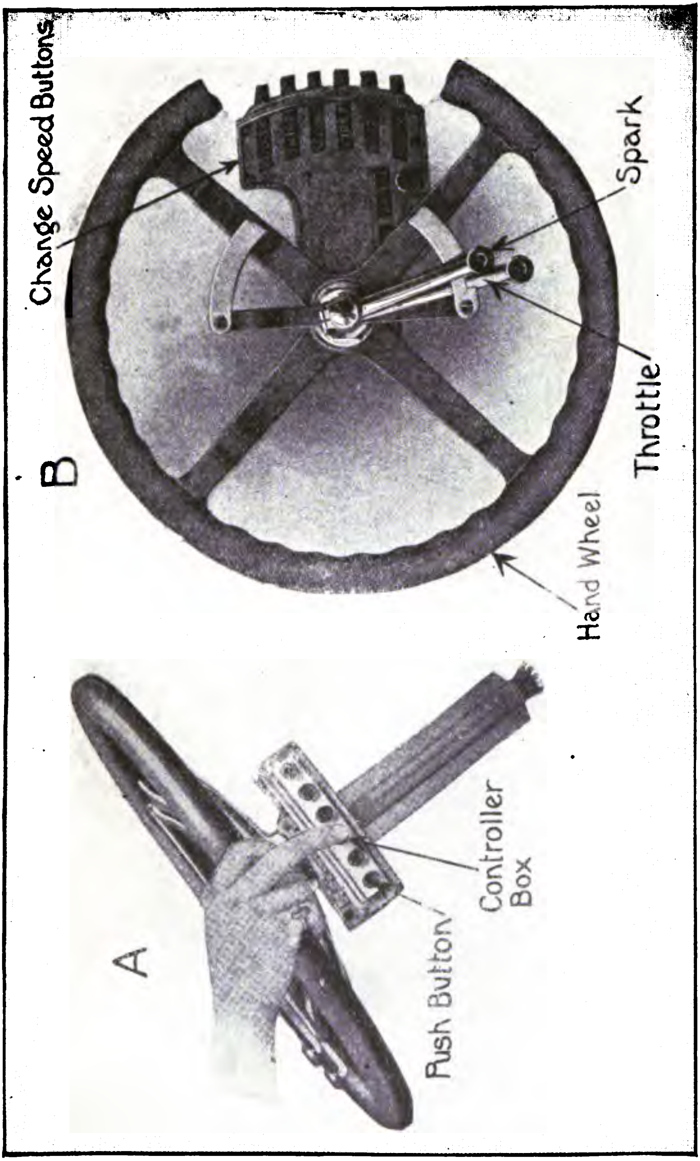

Fig. 280.—How the Change Speed Buttons May Be Located On the Steering Post of Cars Utilizing the Vulcan Electric Gearshift.

the coils, a knife switch controlled by the clutch pedal and a push button located on the steering wheel. All changes of gears are controlled by the knife switch and the push buttons on steering wheel merely arranges the circuit for the particular speed desired. A glance at the cut shows that the clutch pedal moves through a link during the first part of its motion and during the remainder picks up the link and carries it along with it. Thus the first movement is the regular operation of the clutch, but a continued operation of the clutch lever actuates the knife switch.

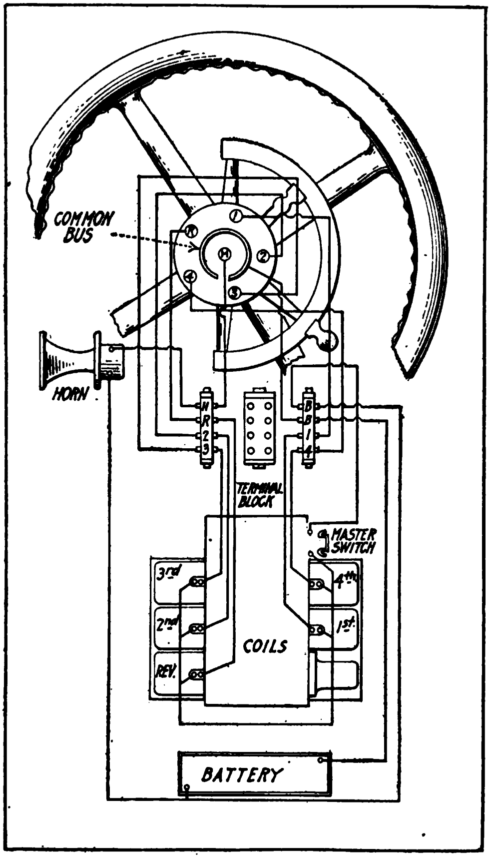

Fig. 281.—Wiring Diagram Showing the Method of Connecting the Vulcan Electric Gear Shift with the Battery and Control Switch.

Current flows from the battery through the solenoid coil and pulls a plunger against a magnet with a force which is given as 40 to 100 pounds. This energy is transmitted through an arm to the gear-shifting fork and gear in exactly the same manner as if the gears were operated with a hand lever. The plungers are normally in a neutral position. When the button is pressed on the control member, current passes through the coil around one of the plungers, drawing

it against the magnet. It is said that the current required to make the shift is about 17 amperes, and it is claimed, further, that three hundred speed changes may be made with less current consumption than is required in starting the motor with an electric starting device.

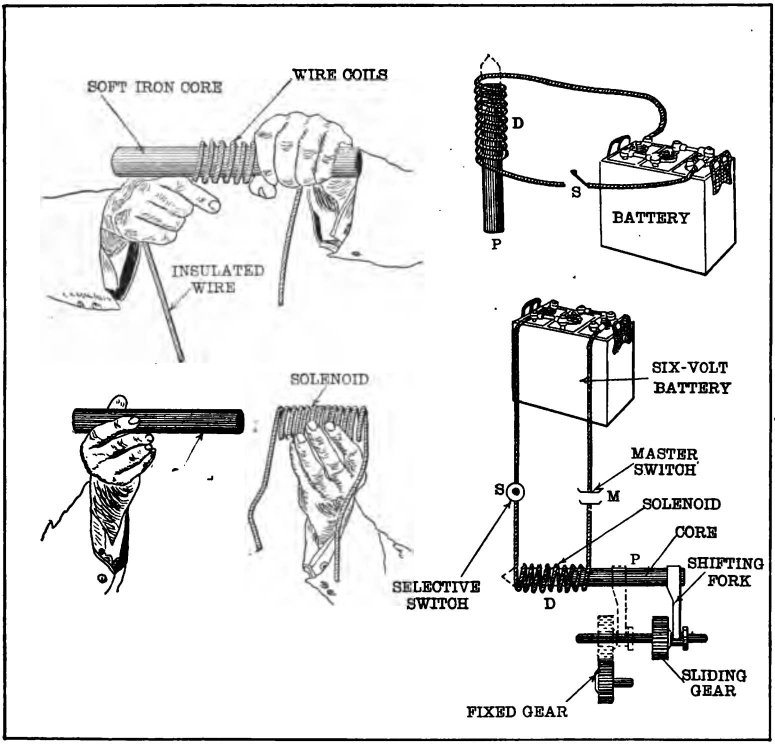

Fig. 282.—Simplified Diagrams Showing How Current Passed Through the Solenoid Will Draw in an Iron Core Piece Which May Be Made to Shift the Gears.

An advantage claimed for this electric gearshift is that the gears cannot be stripped, for the reason that the clutch must be disengaged before a shift can be made and the gears are always in neutral before the coils can accomplish the change. Furthermore,

no two speeds can be utilized at the same time, because each speed is governed independently of the others, and an interlocking device prevents the operator from using any two buttons at one time, even if he should make a mistake or be careless.

The box which contains the switches and solenoid coils shown at Fig. 283 is mounted at the side of the gear box, and it is said that the device adds only 46 pounds to the weight of the chassis. On the S. G. V. car the control buttons are mounted in a neat

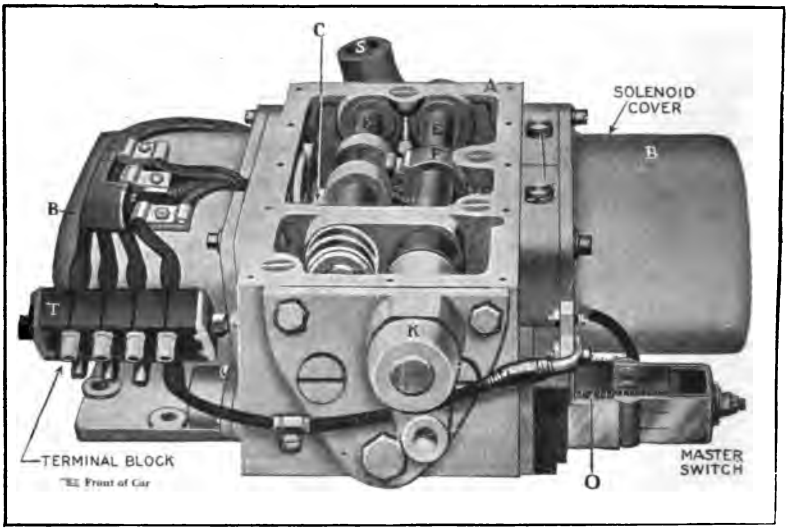

Fig. 283.—The Vulcan Electric Gear Shifting Element Designed for Attachment to Standard Automobile Change Speed Gearing.

aluminum box on the steering wheel, one for each speed, and one for a neutral member. In operation the system is very simple. If, for instance, the fourth speed button is pushed down and the clutch is thrown out and then re-engaged, the car will remain in fourth speed. When driving in traffic on the third speed the driver may set the second speed button and by depressing the clutch pedal fully will automatically shift into second speed. In a similar manner all other changes may be made. The driver need not lift his hand from the wheel in order to accomplish any change in the

gears. Those who have witnessed the operation of this device state that the system is quiet, the only noise being a slight click as the gears engage when changed. This system is also used on the Haynes 1914 automobiles and several other types.

Hartford Electric Brake.—The brake is compact and light, weighing only about 35 pounds. It consists of a small type of the Hartford reversible electric motor with a worm and worm wheel secured to a drum. To this drum is attached a steel cable, the other end of which is fastened to the brake equalizer. (See Fig. 284.)

The most important part of the Hartford brake is the patented controller which is placed within easy reach of the driver's hand, as shown in the illustration. By this new device any desired nicety in the application of the braking effect is obtainable by purely electrical means. Actual demonstration is said to have shown it to be possible to control a 60 horsepower car weighing over 4,000 pounds by the mere pressure of one finger on the operating lever.

A two point control is obtained with this switch, the first point giving enough braking power for regular service, and the second for an emergency stop. Pushing the switch back to its original position immediately disengages the brake. The idea of the whole system may be summed up in a few words by saying that the manual labor usually connected with brake operation is replaced by the work of a high speed, series-wound electric motor which may be fed with current from a storage battery or either 6, 12 or 24 volts (for automobile purposes, or higher voltage, if desired, for other purposes). The armature shaft of this motor carries a worm which drives a worm gear at a reduction of 100 to 1. This worm gear in turn operates a drum through an internal gear at a reduction of 4 to 1, thus giving a total reduction of 400 to 1. On the drum is wound a steel brake-pulling cable which transmits the pull of the motor to the brake mechanism.

When running idle the motor is capable of a speed of 10,000 r.p.m., and when under load it can exert a pull of 1,000 pounds at a speed corresponding to a quick application of the hand emergency brake. After the pull exerted on the cable has attained a value of 1,000 pounds, a slipping clutch prevents any further in-

crease, and a ratchet prevents the brake from slipping off. The powerful pull exerted on the brake cable permits of operating the brakes in oil. It is stated that, the current flow in applying the brake amounts to 40 amperes for two-fifths of a second (presumably for a voltage of 6). The Hartford brake replaces the emergency set and is used constantly in service, the foot brake re-

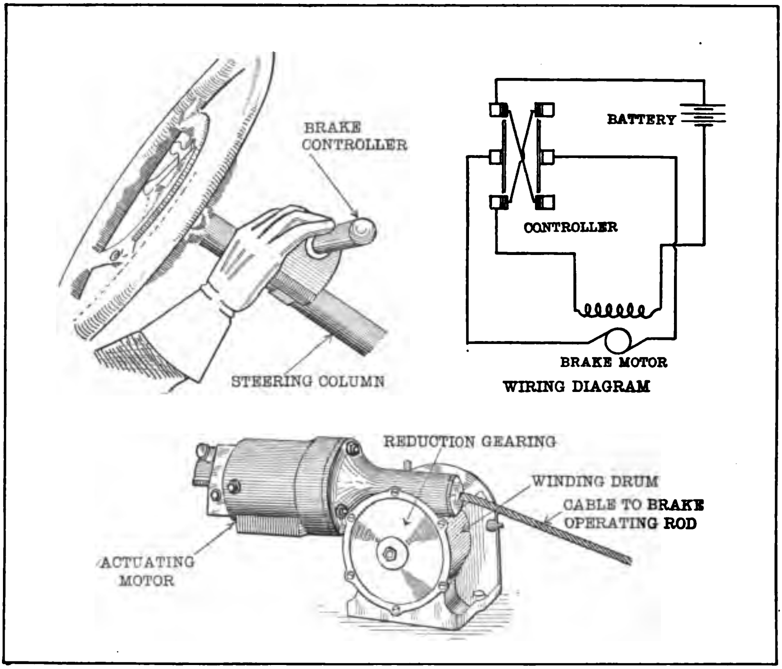

Fig. 284.—How the Hartford Electric Brake Works.

maining as originally installed, for use if wanted. One advantageous feature of the Hartford brake is that it can be easily attached to any existing car, provided it is equipped with a storage battery.

Electric Air Heater.—Nearly every starting difficulty with automobile motors is due to poor carburetion arising from the low temperature of the air and the fuel. It must not be forgotten that

the vaporization of a liquid extracts heat from the gas or air in which the vaporization takes place, so that if we start with cold air it becomes still colder by the time it has taken up the gasoline spray. If the original air temperature is low enough the result of the chilling action of the gasoline may easily result in the latter being thrown down in the manifold and cylinder in liquid form, and in such a case it is only the lighter fractions in the gasoline that mix with the air and give an ignitable gas. Often in actual fact it is the heat generated by the compression of air in the engine that causes the deposited gasoline to vaporize and this sometimes explains why a motor will start after repeated spinning following injection of raw fuel. Since the modern car has always plenty of electricity available it is a natural enough idea to utilize some of it for heating up the air to be used for starting purposes, and one of the neatest devices having this end in view is the Paul preheater, illustrated at A, Fig. 285. This is a section through the apparatus which is intended to be inserted in the middle of the hot-air pipe of the carburetor; the split ends of the preheater in conjunction with the cap nuts enable it to be gripped on flexible pipe if desired, so attachment is easy. Inside the chamber there is a coil of flat metal strip having a fairly high resistance, and the ends of this strip

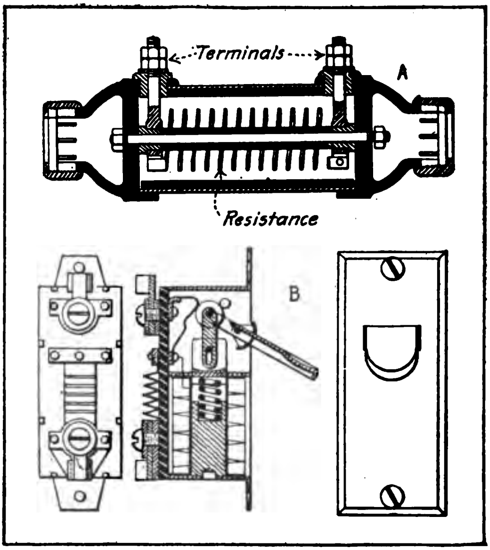

Fig. 285.—Sectional View at A Shows Construction of Air Warmer to Facilitate Carburetion in Cold Weather. Section of a Protective Circuit Breaker Outlined at B.

are fixed to the two terminals shown. A wire is run from the cranking battery to one of these terminals, and the return wire passes through a switch which can conveniently be located in the cowl. To use the heater it should be switched on about half a minute before cranking and the carburetor primed in the usual way. As soon as the motor starts, the exhaust pipe heats up and there is no more need for the preheater, so it can then be switched off.

Automatic Safety Switch.—Fuses in an automobile lighting circuit are always a possible source of trouble, though they happen very seldom. Their purpose is to prevent the wires in the circuit from being overloaded and they are a great safeguard. The trouble comes when some accident causes a short circuit, a rush of current and a "blow." It is then necessary to replace the fuse by a new one, after locating and curing the fault. Thus spare fuses have to be carried, as it is extremely dangerous to cut out a fuse by wiring it up with a bit of copper as is often done in emergency when no spare fuse is available. The Hartman automatic switch at Fig. 385, B, is a simple mechanical device which automatically switches off any circuit if the current in it exceeds the safe amount. It is operated by a small electro-magnet that pulls the contacts apart directly the current becomes too strong. Thus it is as effective as the fuse, while no part of it burns out to give the break in the circuit. All sorts of units are made from a single switch to gang switches that can control every circuit on a car.

Lighting Gas by Electric Spark.—Many automobiles are in use that are not equipped with electric lighting systems, and in which stored acetylene gas is employed for the headlights. An electric lighter which may be used to light the burners without the driver leaving the seat is clearly shown at Fig. 286. This is a type which robs the engine of a spark for an instant while the gas is being lighted, a push button on the dash diverting the high tension current from a secondary wire to the sparking points in the headlights. The gas regulation is very simple, no automatic reduction valve being necessary. A small, high pressure tube leads from the gas tank to a control valve and a regulating valve on the

dash, the former being beside the push button to open or close as desired, while the regulating valve is on the engine side of the dash, and is set as desired for securing the proper pressure at the burners.

Low Voltage Electric Vulcanizers.—The Premier is an electric vulcanizer weighing but two pounds and is shown at Fig. 287. This device operates from the 6-volt storage battery usually carried in the car and is provided with a thermostat which automatically cuts off the current as soon as the vulcanizer attains the correct heat for vulcanizing the repair on shoe or inner tube. It will take any size tire up to 5 in. diameter. The vulcanizer may be used either in a garage or on the road, being simply clamped to the tube or casing, two wires being connected to the battery and contact applied through a button. The simplicity of operation of the device is said to render it of value in quickly healing up small cuts in casings as soon as discovered, thereby preventing moisture from working in and rotting the fabric.

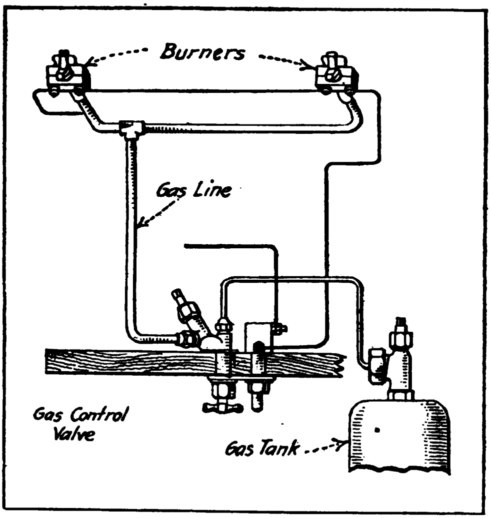

Fig. 286.—How Acetylene Gas May Be Ignited by Electric Spark.

The thing which keeps most motorists from doing their own repairs to punctured air tubes, is the trouble of the process, but the electric type of vulcanizer certainly helps to minimize this. One of the simplest, lightest and smallest machines is the Corbett & De Coursey shown at the right in Fig. 287, which also works off any six volt storage battery and so allows repairs to be made on

the road. It should be quite easy to vulcanize a tube while running the car, as the vulcanizer is so light that it could be held by any passenger without fatigue. With the machine is a thermometer which allows the temperature to be controlled, and also a length

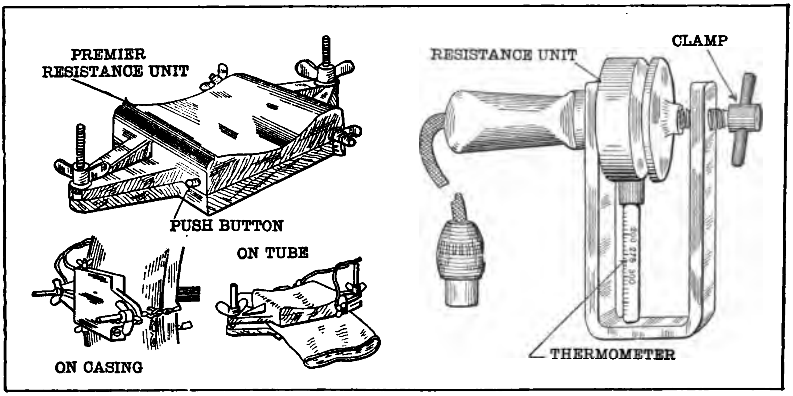

Fig. 287.—Simple Electric Vulcanizers Operating on Storage Battery Current.

of flexible wire furnished with a socket to fit the usual inspection lamp holder on the dashboard.

Simple Rectifier.—The Westinghouse vibrating rectifier shown at Fig. 288 is a compact and simple device invented for charging 6-volt batteries from alternating current. All that is necessary is to connect the attachment plug to a lamp socket and the wires from the binding posts to the battery, and turn the switch. Then leave the battery until charged, without any attention whatever. There are no adjust-

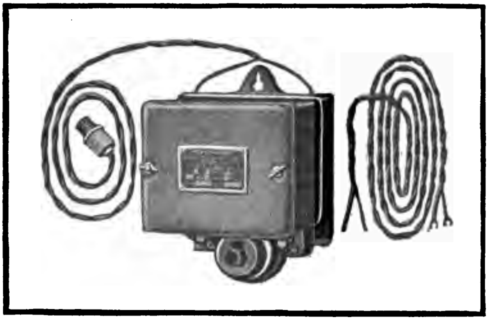

Fig. 288.—The Westinghouse Rectifier for Charging Storage Batteries From Alternating Current.

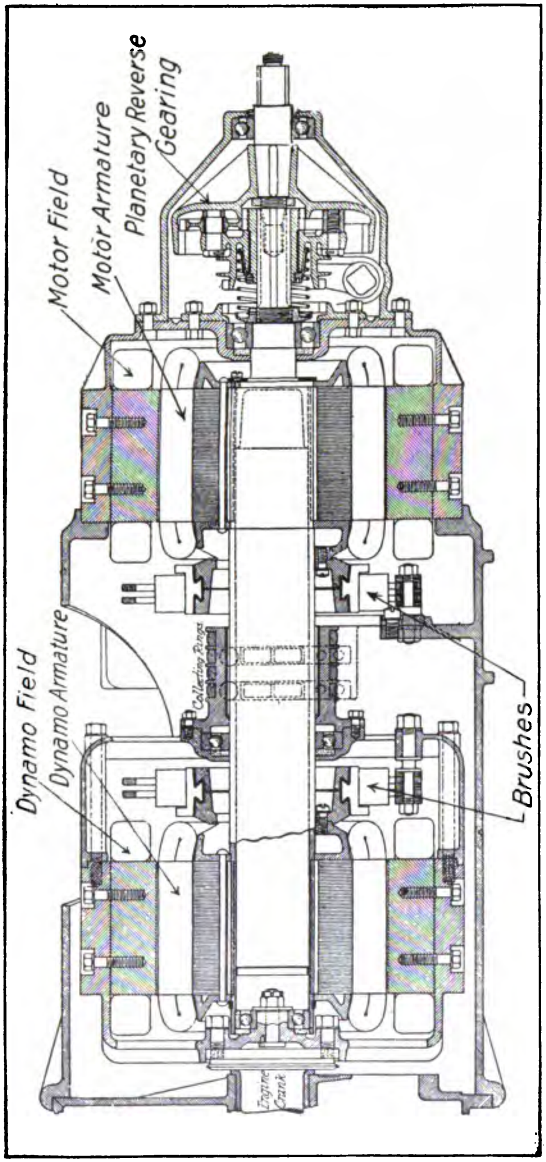

Fig. 289.—Modern Adaptation of the Entz Electric Transmission On the Owen Magnetic Car.

ments to be made and no parts that require frequent renewal. The rectifier can be used on any 100 to 120-volt, 60-cycle circuit, charging three cells at a rate of 8 to 8½ amperes.

The Entz Electric Transmission.—In the Entz electric transmission system shown at Fig. 289 there are two dynamos arranged tandem fashion. These are connected up mechanically in such a way that the efficiency is much higher than that secured by the use of the gasoline-electric systems described at other points in this book. The field frame of the first dynamo is attached to the crankshaft of the engine, and when the armature circuit is closed, the armature will also revolve and thereby propel the car, acting exactly the same as a slipping clutch, the amount of slip being subject to control. The armature is attached directly to the driving shaft, as is that of the motor placed back of the generator. When one transmits power through a slipping clutch, one cannot get any more from it than is put into it. If friction clutch slips fifty per cent., one-half of the energy supplied to it is converted by friction into heat. Similarly in the dynamo or generator of the Entz system, if that member turns only half as fast as the field frame, only one-half of the power supplied to the field is mechanically transmitted. The other half appears in the form of an electric current in the armature circuit. If the armature were short circuited, then all of this electrical energy would be converted into heat. Under conditions of light running, however, when the high gear or direct drive would be used in a car equipped with a sliding gear transmission, the armature of the Entz system is short circuited, but the slippage and loss then amounts to only a few per cent.

When the resistance to car movement is greater, so that a lower gear must be employed in the gear driven cars, with the Entz system, the current produced in the first armature by the slip is sent to the windings of the motor where it produces useful mechanical power. As the armature of the motor is secured to the propeller shaft it transforms the electrical energy produced by the slip at the generator to mechanical power, which supplements that transmitted by the generator armature. The windings of the second machine are such that the electric system can increase the torque or turning effort of the engine three times, at the same time reducing the speed

of driving pinion rotation at the rear axle to one-third that of the engine speed. The engine is permitted to develop its full power, and to turn at such speed as is necessary to secure this effect, and when the resistance to road wheel rotation is such that these must turn slower, instead of slowing up the engine speed it may be kept at the same point and the armature of the generator allowed to slip and generate current, which is then directed to the second machine.

This system was first devised eight or nine years ago, and has been recently reintroduced in an improved and simplified form. The appearance of the unit is clearly shown at Fig. 289. Bolted to the rear of the engine crankshaft is an aluminum housing, which carries the electrical system. Two arms on this crank case rest on the chassis frame to support it. Inside of the housing is another case bolted to a flange at the rear end of the crankshaft. This is the frame of the forward unit of transmission, which carries the field coils, and which acts as a fly-wheel for the engine. To the rear end of the stationary outside housing the field frame of the rear electrical unit, which is intended to be stationary, is attached. The armatures of both units are carried upon a large tubular shaft supported by annular ball bearings. The armature shaft is connected directly to the propeller shaft, and when the car is standing still, the armature shaft is stationary, whereas when running in the high speed position of the controller lever, it turns at practically the same speed as the engine crankshaft.

The action may be described as follows: When the car is standing still with the engine running, the field of the forward electrical unit, which is called the "generator," is rotated with the engine crankshaft to which it is fastened while the armature remains stationary. At this time all electrical circuits are open and there is no tendency for the engine to drive the car. When the controller lever is thrown into the first, or "soft start," position, a circuit is closed through both the generator and the rear unit, which is called the motor. The generator then begins to produce a current which is fed into the motor. At the same time there is power applied to the armature shaft equal to the engine tendency to turn the shaft in the same direction as the crankshaft. The current

produced by the slip owing to the difference in speed between generator field and armature, is being fed into the motor, which also turns the shaft in the same direction as that produced by the mag-

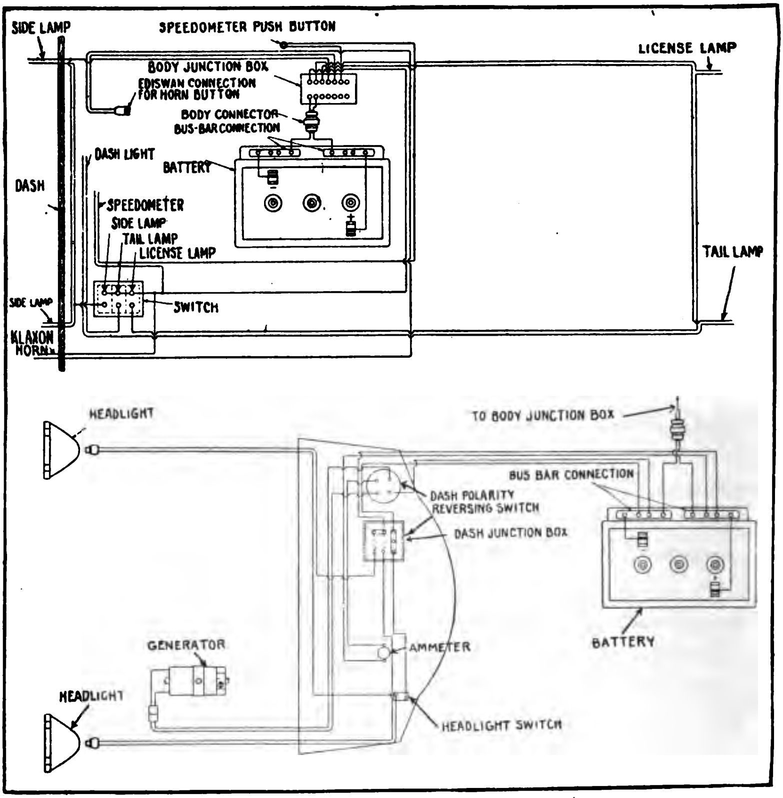

Fig. 290.—Wiring Diagram of Complete Automobile Lighting System Without Starting Motor.

netic clutch. In other positions of the controller up to the high speed position different arrangements of resistances change the speed ratio between engine and propeller shaft, but there are no off points between the various notches, so the application of power to the wheels is not interrupted in changing speeds. When the

high speed position is reached, there is no electrical connection between the generator and the motor. The former is short circuited, and acts as an electrical or magnetic clutch. When it is desired to secure reverse speeds, a mechanically operated planetary reverse gearing is used, which changes the direction of rotation of the driving pinion. When the controller lever is in "off" position, the rear unit is short circuited and it will act as an electrical brake, preventing the car coasting down hill faster than ten miles per hour. When actually applied in a car, current may be shunted from the generating unit to charge a battery, which may be used for lighting and ignition, and the current of which may be directed through the electrical machine when it is desired to start the engine.

Typical Lighting System.—In order to show clearly the wide use that is made of electric current, even on cars not provided with an electric starting motor, wiring diagrams are shown at Fig. 290 which represent the frame and body wiring of a Packard touring car without starting motor. This wiring is used solely for conveying battery current to the lamps and other current-consuming units, which includes a Klaxon horn and speedometer light in addition to the usual lighting equipment of six lamps. Two rear lamps are provided, one of these the usual red signal specified by law, the other is a white light used to illuminate the license tag. In order to make it possible to remove the body from the chassis without destroying the wiring, the current conductors are run in two independent groups, one being secured to the body, the other running through suitable conduits attached to the frame. The upper view shows the body wiring with the storage battery connected, though this member is carried by the frame and has a connector which may be readily broken when desired to join the battery with the body junction box. Among the appliances carried by the body may be mentioned the side lamps, the speedometer and dash lights, the Klaxon horn, and the two tail lamps. The arrangement of the wiring is clearly shown in the illustration, the method of running the wires from the junction box to the various units is clearly defined. Attached to the chassis are the two head lights, the storage battery, and the lighting generator. In this system the generator is used to charge the storage battery, the cur-

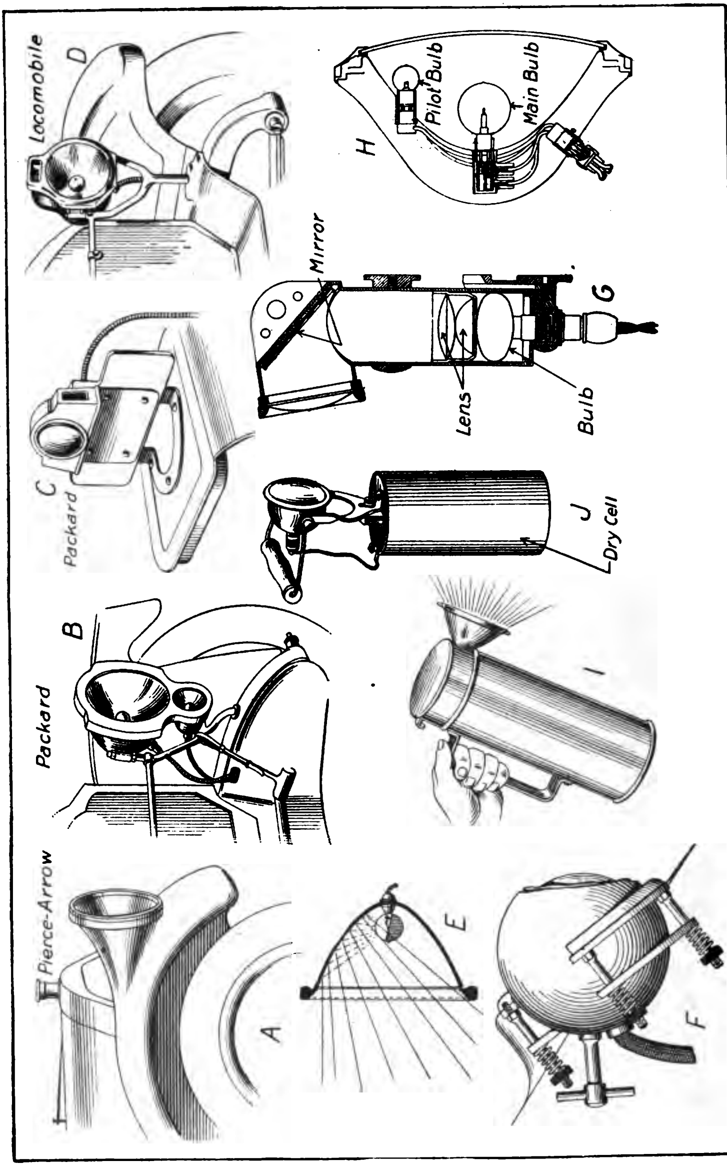

Fig. 291.—Recent Improvements in Electric Lamps for Motor Car Use.

rent going through the usual automatic cutout switch to prevent a reversal of current at such times that the generator is not supplying enough energy to charge the battery. As is true of the diagram presented above, all of the circuits are clearly shown and may be readily followed by any one.

New Things in Electrical Lamps.—Designers of automobiles have not been slow in adapting the lamps used in their electric lighting systems to secure various advantages in mounting or by combining several lamps to simplify installation. At Fig. 291, A, the secure method of attaching the headlights on the Pierce-Arrow automobile by having the lamp case securely attached to the mud guard is shown. The combination of small and high candle-power bulbs in one lamp used on the Packard cars is shown at B. This is made necessary because in some communities the law is very stringent against glare from headlights. When used in a city the small lamps, which are of low candle-power, may be used, while the headlights can be turned on when in the country. The combination of the two lamps used on Locomobile is shown at D. In this the low candle-power bulb is placed in the upper part of the lamp. The secure method of fastening the tail light and license plate carrier on the rear of a Packard mud guard is shown at C.

The internal construction of a double bulb lamp is shown at H. In this the small bulb for city work, which is termed the pilot bulb, is carried in a socket at the top of the reflector in such a way that its rays are reflected to the ground instead of producing a glare, as the main bulb does, because it is at the proper focal point of the parabolic reflector. The pilot bulb is intended for city driving, or when the car is standing idle at night. A number of devices have been introduced to reduce glare, these consisting of special reflectors, or special lens glasses for the front of the lamp. A simple device, which is shown at E, consists of a metal shield, which fits close to the lower half of the headlight bulb, throwing all on the light rays against the upper half of the reflector. It is said that this makes the light upon the roadway more intense than when the deflector is not used but prevents any rays from rising more than four feet from the ground.

A peculiar form of glareless headlight, which is known as the

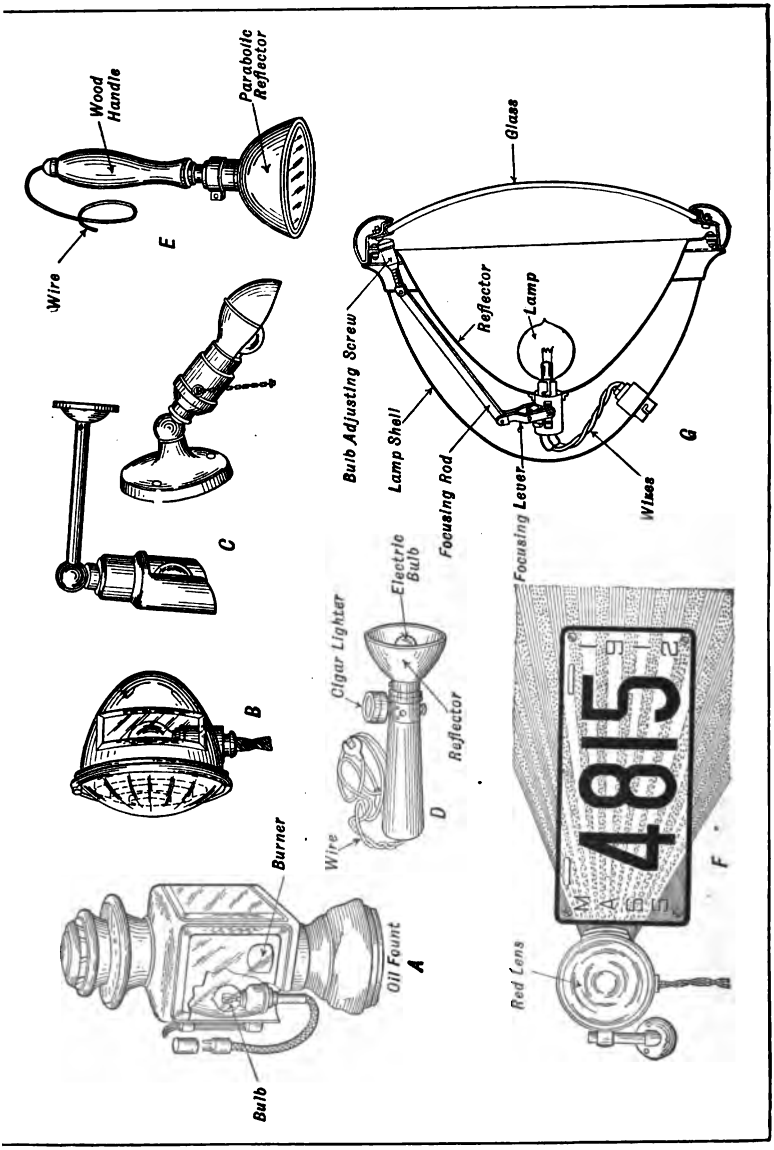

Fig. 292.—Various Forms of Electric Lamps that Can Be Used in Connection with Storage Battery Current.

Roffy, has been recently introduced, this being of the unconventional form shown at Fig. 291, G. The amount of light available depends upon the candle-power of the bulb used. The bulb is car-

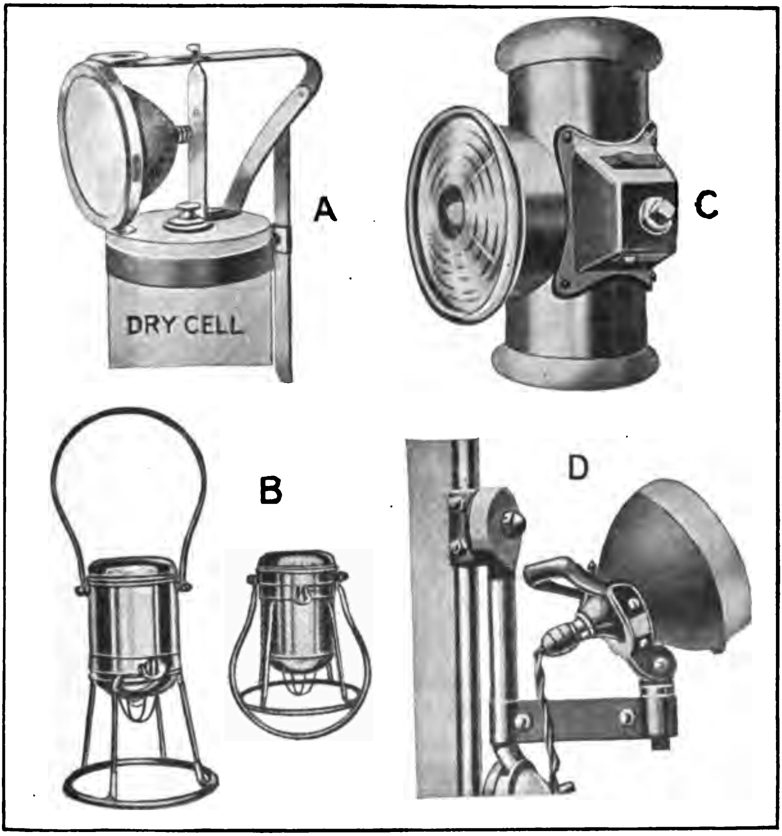

Fig. 293.—Portable Electric Lamps Designed to Operate on Dry Battery Current Shown at A, B and C. Dirigible Search Light Shown at D.

ried at the lower portion of a vertical tube very little over two inches in diameter. The lamp is a special mushroom shape, and immediately above it is a plano-convex condensing lens that collects the light. Immediately above this is another lens of double con-

vex form which converges the light and throws it against the inclined mirror at the top, which in turn throws is through a projection lens, which forms the front glass. This compensates for the color distortion introduced by the condensing lens. The rea-

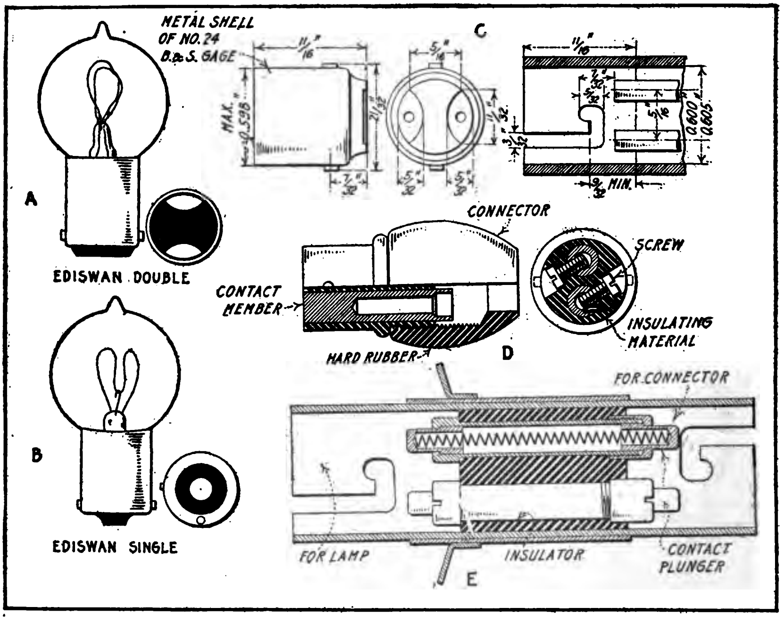

Fig. 294.—Types of Bulbs and Connectors Used on Most Lighting Systems. A—Ediswan Double Contact. B—Ediswan Single Contact. C—Dimensions of Standard Ediswan Double Contact Socket. D—Construction of Connector. E—Ediswan Double Contact Connector for Application to Searchlights.

son why the lamps are glareless is that they throw a very sharply defined cone of light, whose rays are so inclined, due to the angles of the mirror, that the upper beam is parallel to the ground. As the light never rises above its source, which is lower than the height of a man's eyes, there is no glare.

An unconventional form of searchlight for use in the cowl dash is shown at F. This is known as the "eye-ball" type, owing to

the fact that the body of the lamp is spherically formed, which permits of the projected beam being turned at will through an angle of about eighty degrees in both horizontal and vertical planes. The body of the lamp is held between two rings secured to the pressed steel cowl. The lamp can be used as a dirigible searchlight for reading signposts, etc., while, if an extension cord is provided, the lamp shell can be taken directly out of its socket and used to investigate trouble at any point on the car. This is a French invention.

The development of the tungsten filament bulb has made it possible to secure very satisfactory light from ordinary dry cell current.

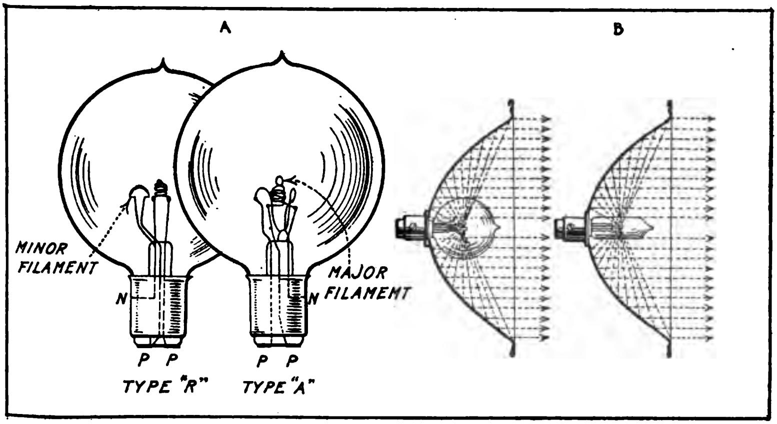

Fig. 295—Recent Developments in Electric Light Bulbs.

rent. Two forms of hand lanterns using dry battery current are shown at I and J. That at J is a simple fitting designed to be attached to any dry battery having a handle by which it may be carried. The form at I has the dry battery inserted in a suitable metal carrying case, which makes a much neater arrangement.

The construction of the various forms of electric lamps used in motor car lighting systems is clearly shown in Fig. 292. The lamp outlined at A is a combination form, designed to use either kerosene or electricity, the former being used only in event of failure of the latter. The side lamp at B is a neat form, intended

to use electricity only. Dash, coil and speedometer lamps are depicted at C. A combination trouble lamp and cigar lighter is shown at D. The trouble lamp at E is an easily portable form and is convenient for use around the power plant, gasoline tank, etc., deriving its current from the regular battery. A combination tail lamp, having red lens at the rear and a white glass at the side to illuminate the number plate, is shown at F. The approved construction of a variable focus electric head lamp is shown at G.

The simple attachment shown at Fig. 293, A, is intended to convert any dry cell to a convenient inexpensive and portable electric lantern. It consists of a reflector carried by a frame that attaches to the terminals of the dry cell. To take the strain from the terminals when the cell is carried, a supplementary clamping band is also secured to the handle, this being fastened to the top of the cell.

The feature of the Federal electric hand lantern shown at B, is that it casts no shadow on the ground beneath it. Instead of having the lamp at the top with a solid base beneath, it has an open foot consisting of a ring and four legs, so that the light is strong immediately under the hand of the person carrying it as well as spread all around. It is fed with current from a special dry cell that is easy to replace, and clips are supplied to fasten the lamp to the running board of the car. It is very compact when folded and the lamp bulb is well protected, while there is a space inside the dry cell where a spare bulb can be put.

For automobiles without electric lighting sets when a moderate illumination is required now and then for short periods, there is a great deal in favor of dry batteries as a source of current, as they are less trouble to look after than oil lamps. The Wireless Autolight depicted at C is a well-made case supplied with a lamp and reflector, glazed in white, green or red. It takes a standard No. 6 cell.

Searchlights of the form shown at D are also becoming popular because these are carried on dirigible brackets attached to the windshield or any other convenient part of the car and the beam of light can be directed against sign boards, around curves, etc., at the operator's pleasure.

Novel Bulb Designs.—Combining two separate and distinct lights in one, the Tulite bulb, shown at A, Fig. 295, is designed solving the headlight glare problem. Two types of this bulb are shown, type R being inserted in the lamp with the minor filament above the major, projecting the light to the roadway at short range. This allows the focusing of a strong headlight as far ahead as desired and, when switching to the minor filament, a good driving light at 40 to 75 feet in front of the car. Type A has a minor filament, mostly surrounding the major and diffuses the light in a general way, covering eight to ten times the area of the major filament when lighted. The standard Tulite bulb is 4 candlepower on the minor and 20 candlepower on the major filament, but other combinations are furnished.

A new type of headlight bulb is the Argon depicted at B, which is filled with nitrogen gas, put into it by pressure. This gas contains a small percentage of argon, about 2 per cent., which, the maker claims, permits the use of a higher voltage for a given filament. The filament is of drawn tungsten wire and is so coiled that when properly focused the lamp does not produce dark rings.

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